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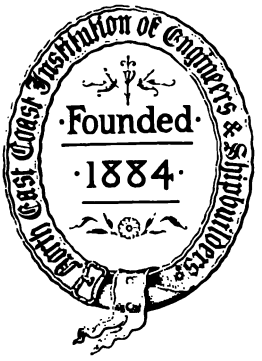

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VOLUME XVII.

SEVENTEENTH SESSION, 1900-1901.

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BOOKS AND TRANSACTIONS OF LEARNED SOCIETIES ADDED TO LIBRARY.

BOOKS.

Ventilation and Heating. B. F. Sturtevant.
Mechanical Draft. By B. F. Sturtevant.
Modern Foundry Practice. Sharp. 1900.
Acetylene. W. B. Lewis. 1900.
Gas, Oil, and Air Engines. B. Donkin. 1900.
Principles of Waterworks Engineering. Tudesbury & Brightmore. 1897.
Pumping Machinery. H. Davey. 1900.
Twenty Years with the Indicator. T. Pray. junr. 1899.
Materials of Construction. J. B. Johnson. 1900.
Motor Vehicles and Motors. W. W. Beaumont. 1900.
Handbook of Testing Materials. 2 vols. Martins. 1899.

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Bureau of Steam Engineering, Navy Department, Washington, U.S. of America.
Canadian Society of Civil Engineers, 112, Mansfield Street, Montreal, Canada.
Cleveland Institution of Engineers, c/o A. Macpherson, Coatham, Redcar.
Engineering Association, 34, Jamieson Street, Sydney, New South Wales, Australia.
Engineers and Shipbuilders in Scotland, 207, Bath Street, Glasgow.
Genio Civile, Alla Direzione della Bibliotica, e dell' Archivio tecnico, del Ministero *dei Lavori Pubblici*, Roma.
Hull and District Institution of Engineers and Naval Architects, Herbert Dunkerley, c/o M. Samuelson, Esq.. Bowlalley Lane, Hull.
Illustrated Official Journal of Patents, Patent Office, London, E.C.
Institution of Civil Engineers, 25, Great George Street, Westminster, London, S.W.
Ipswich Engineering Society, 204, Spring Road, Ipswich.
Iron and Steel Institute, Victoria Mansions, Victoria Street, London, S.W.
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South Wales Institution of Engineers—Hort Huxham, Esq., Park Place, Cardiff.
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Mechanical World, New Bridge Street, Manchester.
Rivista Marittima, Rome.
Shipping World, Effingham House, Arundel Street, London, E.C.
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A.

Abey, Henry, Fairfield, York Road, West Hartlepool ... ... (E)	Jan.	1889
Adams, Cecil T., c/o Messrs. The N.E. Marine Engineering Co., Northumberland Works, Wallsend-on-Tyne (E)	Graduate, Oct.	1891
	Member, Nov.	1897
Adams, Dawson, c/o Messrs. The National Electric Supply Co., Ltd., Bushell Street, Preston, Lancashire (E E)	Graduate, Oct.	1894
	Member, Dec.	1897
Adamson, Alex., St. Andrew's, Chislehurst, London, N.W. ... (S)	Nov.	1885
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	Member, April	1901
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Alexander, Francis H., 42, Percy Park, Tynemouth ... ... (S)	May	1898
Allan, Jas. McNeal, The Poplars, Monkseaton, Northumberland... (E)	Dec.	1886
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Allan, William Jun., c/o Messrs. Richardsons, Westgarth & Co., Scotia Engine Works, Sunderland ... ... (E)	Nov.	1899

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Allan, John, c/o Messrs. Lloyd's Register of Shipping, 12, Oriel Chambers, Water Street, Liverpool ... ... (S) Jan. 1900
Allan, George J., 20, Villa Place, Newcastle-upon-Tyne ... ... (E) Nov. 1898
Allardes, Wm., c/o Messrs. Harland & Wolff, Ltd., Engine Works, Belfast ... ... (E) Nov. 1884
Anderson, Charles William, Mandale House, Mandale Road, Thornaby-on-Tees ... ... (S) Nov. 1900
Anderson, Joseph, Westfield Terrace, Wallsend-on-Tyne ... ... (E) Nov. 1884
Anderson, Thos. James, 2118, Strand, Galveston, Texas, United States of America ... ... (E SUR) Mar. 1898
Andrew, D., 33, Osborne Road, Jesmond, Newcastle-upon-Tyne ...(SUR) Jan. 1885
Andrews, Jas., Eton Villa. Cathcart, Glasgow ... ... (E) Nov. 1884
Angus, W. J., Messrs. Vickers, Sons & Maxim, Naval Construction Works, Barrow-in-Furness ... ... (E) Oct. 1892
Angus, John Chas., c/o Messrs. Robt. Stephenson & Co., Ltd., Hebburn ... ... (E) Nov. 1899
Archbold, Joseph G., c/o Messrs. Blyth Dry Dock Co., Blyth ... (E) Jan. 1889
Arentz, H. S., Horten, Norway ... ... (E) April 1899
Armstrong, Adam Latimer, 3, Bells Terrace, North Shields, ... (S) April 1901
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Arnison, Geo., 36, Fawcett Street, Sunderland ... (N A & SUR) Nov. 1884
Ascroft, Frederick W., 11 Park Street, Lytham ... ... (E) May 1900
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Atkinson, Alfred, 17, The Exchange, Middlesbrough-on-Tees ... (E) May 1901
Atkinson, F. C., 37, Croydon Road, Newcastle-upon-Tyne... ... (E) Dec. 1892
Atkinson, George H., 3, Acclom Street, Hartlepool ... ... (E) Nov. 1898
Atkinson, John Joseph, 7, Swiss Road, Elm Park, Fairfield, Liverpool ... ... (E) Mar. 1891

B.

Bagnall, T. W., The Groves, Winlaton ... ...(F M) Nov. 1893
Bailey, Charles H., Tyne Engine Works, Newport, Mon. ... ... (E) Mar. 1896
Bailey, James, 3, South Avenue, Ryton-on-Tyne ... ... (E) Nov. 1884
Bailey, James N., 3, South Avenue, Ryton-on-Tyne ... ... (E) Nov. 1898
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Baines, Geo. Henry, c/o Messrs. W. Gray & Co., Central Marine Engine Works, West Hartlepool ... ... (E) Oct. 1888
Baird, Alexander, 9, Delaval Road, Whitley Bay, Northumberland (E) Oct. 1898
Baird, George, 24, Cecil Street, North Shields ... ... (E) Oct. 1892
Baird, Robert, 13, Hylton Terrace, North Shields ... ... (E) Jan. 1890
Baker. E. F., H.M.S. "Magdala," Bombay, British India ... ... (E) { Graduate, Nov. 1892 / Member, Feb. 1898
Barclay, James. Lloyd's Register of Shipping, Swansea ... ...(SUR) Nov. 1888
Barley, C. J., c/o Messrs. The London Electric Supply Corporation, Stowage Wharf, Deptford, London, S.E. ...(E) { Graduate, Feb. 1885 / Member, Dec. 1886
Barnard, Robert, Stanwideville, Tynemouth ... ... (E E) Mar. 1899
Barnett, James Rennie, Westfield, Crookston, Renfrewshire, N.B. (S) Oct. 1889

ELECTED.

Barrett, A., Dalton House, West Hartlepool ... ... (E) May 1896
Barron, T. G., Hobourne, Elswick Road, West Hartlepool ... (E) Oct. 1888
Bateman, John, Vane Terrace, Darlington ... ... (E) Mar. 1901
Batey, John Thomas, 25, Harrison Place, Newcastle-upon-Tyne ... (S) Nov. 1885
Batliboi, Jehangir Framji, 71, Apollo Street, Fort, Bombay ... (E) Dec. 1888
Baxter, J., 26, Simonside Terrace, Heaton, Newcastle-upon-Tyne (E) Nov. 1884
Beadon, D. C., "Stoneham," Beech Grove Road, Newcastle-upon-Tyne... ... ... (E) Jan. 1885
Beilby, Norman Harry, 1, Kingsley Place, Newcastle-upon-Tyne... ... ... (E) { Graduate, Dec. 1893 / Member, Dec. 1899
Bell, Geo. Arthur, 48, Crown Street, Newcastle-upon-Tyne (E) { Graduate, Oct. 1890 / Member, Jan. 1894
Bell, Joshua Robson, 40, Hill Street, Jarrow-on-Tyne ... ... (S) Mar. 1899
Bell, William, Messrs. Cleland's Slipway Co., Willington Quay-on-Tyne ... ... (E) Nov. 1888
Bennet, Percy M., 190, Heaton Road, Newcastle-upon-Tyne ... (E E) Dec. 1899
Berkley, A. B., 11, Croft Terrace, Jarrow-on-Tyne ... ... (E) Mar. 1887
Berven, Ferdinandt, c/o Messrs. Bergens Mekaniske Værksted, Bergen, Norway ... ... (S) April 1901
Bigge, D. L. Selby, 27, Mosley Street, Newcastle-upon-Tyne ... (E E) Nov. 1894
Billetop, Torben Christian, 3, Guildford Place, Heaton, Newcastle-upon-Tyne ... ... (E) Nov. 1896
Bindesböll, S. C. W., Aktieselskabet Helsingors Jernskibs- og Maskinbyggeri Helsingor, Denmark ... ... (S) Nov. 1884
Binns, Aubrey B., 23, Thornhill Terrace, Sunderland ...(E) { Graduate, Oct. 1894 / Member, Dec. 1899
Black, J., 1, Church Street, West Hartlepool ... ... (E) Nov. 1888
Black, Wm., 1, Lovaine Place, Newcastle-upon-Tyne ... ... (E) Jan. 1885
Blackett, Walter, 19, Valletort Road, Stoke, Devonport ... ... (E) { Graduate, Nov. 1886 / Member, Nov. 1892
Blackie, Thomas Reid, Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London ... ... (SUR) Nov. 1890
Blake, James, Northbrook, Linthorpe, Middlesbro' ... ... (E) Nov. 1899
Blaylock, Robert, 10, Greenbank Crescent, Darlington ... ... (F M) Dec. 1900
Blenkinsop, John N., Marine Supt. Engineer, Great-Eastern Railway, Parkeston Quay ... ... (E) Oct. 1885
Blomberg, Carl A., 2262, North 19th Street, Philadelphia, Pa., United States of America ... ... (E) Oct. 1896
Blow, Charles, 52, Falmouth Road, Heaton, Newcastle-upon-Tyne... ... ... (E) Nov. 1898
Blumer, Wm., Woodside, Sunderland... ... ... (S) Dec. 1886
Boddy, John, 96, Dock Street, Newport, Monmouthshire ... ... (E) Dec. 1888
Bodin, Lauritz M., 58, John Street, Sunderland ... ... (E & SUR) Dec. 1889
Bomphrey, Archibald M., 25, James Watt Terrace, Barrow-in-Furness ... ... (S) Oct. 1898
Bone, W. J., 61, Linskill Terrace, North Shields ... ... (S) Dec. 1884
Bonnyman, James Smith, 64, Plasturton Avenue, Cardiff... ... (E) Nov. 1889
Boolds, Jas. H., c/o Messrs. Vickers, Sons, & Maxim, Naval Construction Works, Barrow-in-Furness ... ... (S) Oct. 1886
Booth, Edward Spence, Box 5124, Boston, U.S. America ...(M S & N A) Oct. 1889
Booth, John William, Union Foundry, Rodley, near Leeds ... (E) April 1892

ELECTED.

Borrie, Peter, 4, Oxford Terrace, Stockton-on-Tees ... ... (E) Nov. 1900
Borrowman, William Cameron, Wh.Sch., Newstead, Grange Road, West Hartlepool ... ... (E) Oct. 1898
Bosi, Guiseppe, Presso Rastelli, Sampierdarena, Genoa, Italy (E & NA) Jan. 1894
Bowden, John, Sheriff Mount, Gateshead-on-Tyne (E) { Graduate, Jan. 1894 / Member, Oct. 1898
Boyd, Arthur, Lloyd's Register of Shipping, Bute Docks, Cardiff (E SUR) May 1895
Boyd, Wm., North House, Long Benton, Newcastle-upon-Tyne ... (E) Nov. 1884
Boyt, John T., 302, Walnut Street, Philadelphia, Pa., U.S.A. ... (E) Nov. 1893
Bramwell, Balfour, c/o Messrs. Harland & Wolff, Engine Works, Belfast ... ... (E) { Graduate, Nov. 1886 / Member, Nov. 1887
Brankston, R. T., 36, Hawthorn Street, Newcastle-upon-Tyne ... (E) Nov. 1884
Brash, James, c/o Messrs. Ernest Scott, Mountain & Co., Close Engine Works, Newcastle-upon-Tyne ... ... (E E) Nov. 1897
Brew, George, c/o Messrs. Furness, Withy & Co., steamship owners, Montreal ... ... (SUR & C E) May 1896
Brigham, Robert F., 5, Argyle Terrace, South Shields ... ... (E) Mar. 1897
Broadbent, Frank, c/o Messrs. J. H. Holmes & Co., Portland Road, Newcastle-upon-Tyne ... ... (E E) Nov. 1893
Brock, Henry W., c/o Messrs. Wm. Denny & Bros., Dumbarton (E & S) Nov. 1899
Brockett, Charles, 35, Milton Road, West Hartlepool ... ... (E) Feb. 1899
Brotherston, James, 23, Nelson Street, Sunderland ... ... (E) Oct. 1895
Brown. Eugene, c/o Messrs. J. H. Holmes & Co., Portland Road, Newcastle-upon-Tyne ... ... (E E) Feb. 1886
Brown, Geo. Matthew, Maple Cottage, Clarence Road, Sidcup, Kent ... ... (E) { Graduate, April 1895 / Member, Nov. 1897
Brown, James, c/o Messrs. Palmer's Shipbuilding Co., Jarrow-on-Tyne ... ... (E) Mar. 1891
Brown, Percy J., Salem Cottage, Sunderland ... ... (E) May 1899
Brown, Robson, 32, Salmon Street, South Shields ... ... (E) Nov. 1889
Brown, T. R., 37, Stansfield Street, Sunderland ... (E) { Graduate, May 1885 / Member, Oct. 1886
Brown, William, c/o Messrs. Siemens Brothers & Co., Woolwich... (E) April 1887
Browne, Sir B. C., Westacres, Benwell, Newcastle-upon-Tyne (C E) Jan. 1885
Buchanan, John H., Oswald Chambers, 5, Oswald Street, Glasgow (SUR) Oct. 1888
Buckland, H. B., Baltic Chambers, Quayside, Newcastle-upon-Tyne (E) Nov. 1885
Buckwell, George William, Board of Trade Surveyor's Offices, Sunderland... ... ... (SUR) Oct. 1896
Bull, John Catharinus, 29, Bexley Heath, Erith, Kent ... ... (E) Oct. 1892
Bulmer, Frederick Charles, Fairholm Road, Benwell, Newcastle-upon-Tyne ... ... (E) { Graduate, May 1894 / Member, Oct. 1895
Bulmer, John, 2, Graingerville North, Newcastle-upon-Tyne ... (E) Mar. 1886
Bulmer, John George, 34, Brighton Grove, Newcastle-upon-Tyne (E) May 1894
Bulmer, Septimus, 49, Brighton Grove, Newcastle-upon-Tyne... ... ... (E) { Graduate, May 1894 / Member, Dec. 1899
Burbidge, Alfred H., Backwell Rectory, Bristol ... (E) { Graduate, Oct. 1895 / Member, Oct. 1898
Burley, M. F., 14, Croft Terrace, Jarrow-on-Tyne ... ... (F) Nov. 1899
Burnett, Norman, C, Lombard Street, Newcastle-upon-Tyne ... (E) Oct. 1891
Burney, Charles E., Lloyds Registry of Shipping, 12, Oriel Chambers, Liverpool ... ... (SUR) Nov. 1898

ELECTED.

Bushell, Chas. A., 1, Benton Terrace, Newcastle-upon-Tyne (N A & SUR) Nov. 1893
Butterfield, George, 4, Kayll Road, Sunderland ... ... (S) Nov. 1884
Butterworth, George Herbert, 41, Brook Road, Bootle, nr. Liverpool (E) Nov. 1899
Buchan-Sydserff, Thos., c/o A. G. Mumford, Esq., Culver Street Ironworks, Colchester ... ... (E) Oct. 1888
Byers, Wm. Lumsden, 11, Norfold Street, Sunderland ... ... (E) May 1900

C.

Cairns, C. W., M. Sc., 4, Hollow Lane, New Barns, Barrow-in-Furness ... ... (E) { Graduate, Nov. 1894 / Member, Dec. 1897
Carr, Wilson Story, 13, Mosley Street Newcastle-upon-Tyne ... (C E) May 1900
Cama, Nusserwanji Bomanji, Sleater Road, Tardeo, Bombay, British India ... ... (E) Dec. 1888
Cameron, Angus, c/o Messrs. Sir James Laing & Sons, Deptford Yard, Sunderland ... ... (S) Nov. 1892
Campbell, J. Jennings, Bureau Veritas Register of Shipping, 155, Fenchurch Street, London, E.C. ... ... (E) Oct. 1888
Campbell, John M., 4, Winchester Terrace, Newcastle-upon-Tyne (N A) April 1895
Campbell, Thomas, 129, Bute Road, Docks, Cardiff ... ... (S) Mar. 1894
Camps, H. E. J., Messrs. Camps & Piercy, 102, Fenchurch Street, London, E.C. ... ... (S) Oct. 1894
Canning, Chas. E., c/o Messrs. Burmeister & Wains, Ship-builders, Copenhagen, Denmark ... ... (S) { Graduate, Dec. 1897 / Member, Nov. 1899
Cannell, Frank, Messrs. H. Parry & Son, Lisbon ... ... (E & S) Nov. 1887
Carney, J. H., Glengariffe, Stow Park, Newport, Monmouth ... (E) Mar. 1897
Carstons, Samuel, Messrs. Burmeister & Wains, Maskin-og Skibsbyggeri, Copenhagen, Denmark... ... ... (S) Dec. 1887
Carter, Geo. J., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Elswick Shipyard, Newcastle-upon-Tyne ... ... (N A) Dec. 1897
Casey, James, 10, Philpot Lane, London, E.C. ... ... (E) Nov. 1891
Ceuvel, John L., 763, Gulgenstug, Naarden, Holland ... ... (E) Mar. 1886
Chambers, John, 114, Sidney Grove, Newcastle-upon-Tyne ... (E) Dec. 1897
Chapman, Harry Reynolds, Messrs. Clarke, Chapman & Co., Gateshead-on-Tyne ... ... (E) Mar. 1893
Charlton, Henry, 1, Millfield Terrace, Gateshead-on-Tyne ... (E) Nov. 1884
Charlton, R. B., Jun., Manors Railway Station Works, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Charlton, T., 25, Lincoln Street, Gateshead-on-Tyne ... ... (E) Nov. 1884
Chaston, Edward Catmore, 27, Larkspur Terrace, Newcastle-upon-Tyne ... ... (E) Oct. 1894
Cherry, Thos. Wm. Fry, c/o Messrs. Tyne General Ferry Co., St. Peter's, Newcastle-upon-Tyne ... ... (E) Oct. 1894
Chicken, Thomas, c/o Messrs. Newport Engineering and Ship Repairing Co., Newport, Monmouth ... ... (E) Oct. 1892
Chilton, Joseph, 73 Theresa Street, Blaydon-on-Tyne ... ... (E) Dec. 1899
Chisholm, Alexander, c/o Messrs. Wigham Richardson & Co., Neptune Works, Walker-on-Tyne ... ... (S) Mar. 1893
Christie, C. J. D., Neptune Works. Walker-on-Tyne ... ... (S) Nov. 1884
Christie, J. D., Woodside, Tynemouth ... ... (S) Nov. 1884
Christie, Reginald, Woodside, Tynemouth ... ... (E E) Mar. 1900
Christie, David M., 95, Great Western Road, Glasgow ... ... (E) Mar. 1900

ELECTED.

Clague, James Henry, c/o Messrs. Laird Bros., Birkenhead Ironworks, Birkenhead ... ... (S) — Graduate, April 1891; Member, May 1894

Clark, Charles, c/o Messrs. Robert Irvine & Co., Tower Chambers, West Hartlepool ... ... (E) Jan. 1897

Clark, George, Southwick Engine Works, Sunderland ... (E) Feb. 1888

Clark, Henry, Southwick Engine Works, Sunderland ... ... (E) Oct. 1887

Clarke, Harry, Lloyd's Register of Shipping, Newport, Monmouth (E) Mar. 1897

Clarke, Henry Trevisa, Deptford Shipyard, Deptford, Sunderland (S) Mar. 1892

Clarke, William Henry, 49, Vanburgh Park, London, S.E. ... (E) Dec. 1896

Cleghorn, Alexander, 10, Whittinghame Drive, Kelvinside, Glasgow (E) Feb. 1897

Coates, Matthew C., 26, Denmark Street, Gateshead-on-Tyne ... (E) Nov. 1897

Cohn, William M., 2, Marine Terrace, North Shields ... ... (S) Nov. 1893

Coleby, James W., 42, Burns Terrace, Willington Quay-on-Tyne ... ... (E) — Graduate, Oct. 1891; Member, Jan. 1894

Coletti, Silvio, 15, Via Masone Bergano, Italy ... ... (S) Dec. 1895

Common, John B. A., Lloyd's Register of Shipping, 342, Argyle Street, Glasgow ... ... (E) April 1896

Conràdi, Carl, Prinsens Gade 2b, Christiania, Norway ... ... (E) Nov. 1884

Consiglio, Luigi, 8, Via Paterno, Palermo ... ... (N A) Nov. 1890

Cookson, John A., 4, Durham Road, Gateshead-on-Tyne ... ... (E) — Graduate, Dec. 1895; Member, Nov. 1897

Cooper, Burjorjee S. N., Sea View, Mahim, Bombay, British India (E) May 1900

Coote, Arthur, Messrs. R. & W. Hawthorn, Leslie, & Co., Hebburn-on-Tyne ... ... (S) Nov. 1884

Cornish, H. P., Lloyd's Register of Shipping, 28, Kattendyk, Ouest Quai, Antwerp ... ... (E) Oct. 1888

Couche, Henry Drew, c/o Messrs. Laird Bros., Birkenhead Works, Birkenhead ... ... (S) Oct. 1891

Coull, Alex. B., Baltic Chambers, Newcastle-upon-Tyne ... ... (C E) Jan. 1898

Courtier-Dutton, W. T., British Corporation Registry of Shipping, 69, St. Vincent Street, Glasgow... ... ... (S SUR) April 1890

Cowan R., 14, Osborne Avenue, South Shields ... ... (E) Dec. 1896

Cowens, William Edward, c/o Messrs. John Abbot & Co., Gateshead-on-Tyne ... ... (E) Dec. 1889

Craggs, Adolphus, Ivy House, Pelton, Chester-le-Street (E) — Graduate, Dec. 1897; Member, Nov. 1899

Craggs, Ernest H., Messrs. R. Craggs & Sons, Middlesbrough ... (S) Oct. 1888

Craig, Robert, Pageland House, Grange Road, West Hartlepool ... (E) Nov. 1892

Crofton, Charles, 17, Albany Gardens, Whitley Bay, Northumberland ... ... (E) Nov. 1895

Crookston, John, 72, Mark Lane, London, S.E. ... ... (E) Mar. 1896

Cruddas, W. D., Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Elswick, Newcastle-upon-Tyne ... ... (E) Dec. 1884

Cruickshank, Alexander, H.M. Naval Dockyard, Gibraltar ...(SUR) Mar. 1892

Cumming, William, c o Mr. Hyslop, Hampton House, Grey Street, St. Kilda, Melbourne, Australia ... ... (E) Mar. 1896

Cummins, W. R., 15, Victoria Street, Loughborough ... ... (E) Nov. 1884

Cunliffe, Tom Arthur, 26, Ormonde Street, Chester Road, Sunderland ... ... (E) Feb. 1897

D.

Dale, John, 13, Ewesley Road, Chester Road, Sunderland ... (E) Mar. 1897

Dalrymple, Wm., Myrtle Cottage, nr. Cleadon, Sunderland ... (E(Dec. 1886

		ELECTED.
Dalrymple, William, Jun., 42, Cleveland Road, Sunderland ...	(E)	Dec. 1895
Darling, W. J., Lloyd's Register of Shipping, Dock Chambers, Barry	(S)	April 1887
Darney, John, c/o Messrs. Short Bros., Pallion, Sunderland ...	(S)	Nov. 1884
Davidson, Alexander, 15, North View, Heaton, Newcastle-upon-Tyne	(S)	Nov. 1900
Deighton, William, Messrs. Deighton's Patent Flue Co., Vulcan Works, Pepper Road, Leeds	(E)	Nov. 1897
Denny, Archibald, c/o Messrs. Wm. Denny & Bros., Dumbarton ...	(S)	Dec. 1891
Denny, Leslie, c/o Messrs. Wm. Denny & Bros., Dumbarton ...	(S)	Nov. 1899
Denny, Peter, Bellfield, Dumbarton	(E & S)	Nov. 1899
De Rusett, Edwin W., Warden House, Percy Park Road, Tynemouth	(S)	Nov. 1890
Detchon, John, 115, Bell Terrace, Newcastle-upon-Tyne	(E)	Feb. 1899
Dick, F. W., c/o Messrs. Park Gate Iron and Steel Co., Ltd., Park Gate, Rotherham	(I & S M)	Oct. 1891
Dickie, James, 428, Mississippi Street, Potrero, San Francisco, California, U.S.A.	(S)	Mar. 1894
Dickie, John P., 18, Brinkburn Terrace, South Shields	(E)	Graduate, Mar. 1898 Member, May 1900
Dickinson, F. T., 23, Park Place W., Sunderland ...	(E)	Graduate, May 1885 Member, Oct. 1886
Dickinson, James C., The Cloisters, Sunderland	(E)	Nov. 1884
Dickinson, John, Park House, Sunderland	(E)	Nov. 1884
Dickinson, W., The Club, Sunderland	(E)	Nov. 1884
Dietze, F. G., Messrs. The Hamburg South American Steam Ship Company, Hamburg	(E)	Nov. 1893
Dippie, Joseph Robt., 130 Albert Road, Jarrow-on-Tyne	(S)	April 1900
Dixon, James, c/o Messrs. Ropner & Sons, Shipbuilders, Stockton-on-Tees	(E)	Dec. 1893
Dixon, John Rochester, 79, Osborne Road, Newcastle-upon-Tyne	(E)	Graduate, Oct. 1887 Member, Feb. 1893
Dixon, Sir Raylton, Cleveland Shipyard, Middlesbrough	(S)	Feb. 1888
Dixon, William John, R.N., 10, Granville Road, Newcastle-on-Tyne	(E)	Graduate, Mar. 1896 Member, Nov. 1899
Dobson, Henry James, c/o Messrs. William Dobson & Co., Newcastle-upon-Tyne	(S)	Graduate, Oct. 1891 Member, Feb. 1898
Dobson, John T., 42, Ripon Street, Sunderland	(S)	May 1899
Dobson, William, Shipbuilder, Walker-on-Tyne	(S)	Nov. 1888
Donald, James, 58, General Gordon Terrace, Sunderland	(S)	Nov. 1884
Donkin, George, St. Andrew's Engine Works, Newcastle-upon-Tyne	(E)	Oct. 1892
Donovan, J. W., 5, Ash Place, Newcastle Road, Sunderland ...	(E)	April 1885
Dos Santos, Apolinaris J., Rio Grande-do-Sul, Brazil ...	(SUR)	Nov. 1891
Douglas, John F., c/o Messrs. Ramage & Ferguson, Leith... ...	(E)	Jan. 1888
Dove, Herbert J., 25, Ashfield Terrace W., Newcastle-upon-Tyne	(E)	Nov. 1896
Downing, Nicholas, Glenbrooke, Victoria Avenue, Norton Road, Stockton-on-Tees	(I F)	Oct. 1894
Dowsen, Chas., 21, Croft Terrace, Jarrow-on-Tyne...	(E)	Dec. 1885
Doxford, Albert Ernest, M.A., 1, Grange Crescent, Sunderland...	(E)	Graduate, Oct. 1890 Member, Nov. 1893
Doxford, Charles D., Bainbridge Holme, Tunstall Road, Sunderland	(S)	Nov. 1884
Doxford, Robert P., Pallion Engine Works, Sunderland	(E)	Nov. 1884

ELECTED.

Doxford, Sir, W. Theodore, M.P., Pallion Shipyard, Sunderland... (S) Nov. 1884
Dressler, Gustav, 22, Fichistr, Hamburg, Eilbeck ... ... (E) Jan. 1900
Duckitt, Jno., Leazes Gate Villa, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Duckitt, John Brentnall, 20, George Lane, Woodley, *via* Stockport, Cheshire ... ... (E E) { Graduate, Oct. 1888 / Member, April 1895
Duckitt, Talbot, 56, Beacon Road, Loughborough (E E) { Graduate, Oct. 1891 / Member, Oct. 1898
Dudgeon, F. S., 30, Great St. Helens, London, E.C. ... ... (E) Feb. 1885
Dugdale, William H., Wear Dock Yard, Sunderland ... ... (S) Mar. 1894
Duguid, Robert, c/o Messrs. Harland & Wolff, Drawing Office Department, Belfast ... ... (S) Oct. 1892
Dunlop, John, c/o Messrs. Clyde Shipbuilding and Engineering Co., Glasgow ... ... (S) Mar. 1898
Dunlop, William, c/o Messrs. Odero fu Alessº., Sestri-Ponente, Italy (E) Mar. 1888
Dykes, George, Lloyd's Register of Shipping, Steinhoeft 3, Hamburg ... ... (S) Jan. 1893
Dykes, James, 82, Park Road, Newcastle-upon-Tyne ... ... (E) May 1885
Dykes, John, Lloyd's Register of Shipping, 12, Oriel Chambers, Liverpool ... ...(SUR) Oct. 1889

E.

Eason, Thos., 30, Rothwell Road, Gosforth, Newcastle-upon-Tyne (E) April 1899
Edminson, Frank A., Ormidale, Otterburn Villas, Newcastle-upon-Tyne ... ... (S) { Graduate, Nov. 1893 / Member, Nov. 1897
Edmiston, Jas. B., Ivy Cottage, Highfield Road, Walton, Liverpool (E) Nov. 1886
Edwards, James Harry, Jun., High Docks, South Shields ... ... (S) Mar. 1893
Eeles, Robert, Queen Street, Newcastle-upon-Tyne ... ... (E) April 1889
Elder, Edward, c/o Messrs. John Brown and Co., Clydebank, Glasgow ... ... (S) { Graduate, Nov. 1890 / Member, Oct. 1892
Elliott, William D., Hessle, Hull ... ... (E) Nov. 1894
Eltringham, Harry, Messrs. J. T. Eltringham & Co., Stone Quay, South Shields ... ... (S) Feb. 1901
English, Thos. (Lieut.-Col.), Hawley, near Dartford, Kent ... (E) Oct. 1890
Eshelby, William, 13, Brankingham Terrace, Norton Road, Stockton-on-Tees ... ... (E) Feb. 1888
Evans, Lewis, c/o Ralph Carr, Esq., Maritime Buildings, King Street, Newcastle-upon-Tyne ... ...(SUR) Dec. 1890
Evans William, Superintendent Engineer, Rosedene, Whitchurch, Cardiff ... ... (E) Nov. 1889
Eyres, Reginald J., 4, Cedars Crescent, Sunderland ... (C E) Feb. 1900

F.

Fairbairn, James, 54, Amberley Street, Sunderland (E) { Graduate, May 1885 / Member, April 1895
Farina, A. J., 63, Quayside, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Farminer, A. E., c/o Messrs. Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (SUR) Jan. 1900
Farquharson, Geo. James, c/o Messrs. Elder, Dempster & Co., Luisenhof, Neue Gröninger Strass, 1, Hamburg ... ... (E) April 1899

ELECTED.

Fenwick, James, B.Sc., C.E., 19, Bridge Street, Sydney, New South Wales ... ... (E) Oct. 1892

Ferguson, Wm. Deeble, Iveagh Chambers, Belfast ... ... (CE) Feb. 1901

Ferrier, Robert M., B.Sc., Durham College of Science, Barras Bridge, Newcastle-upon-Tyne ... ... (E) Nov. 1892

Fettes James, c/o Messrs. R. E. Mudie & Sons, Marine Buildings East, Dock Street, Dundee ... ... (E) May 1899

Field, Arthur M. C., 7, Mayfield Road, Gosforth, Newcastle-upon-Tyne ... ... (E E) Jan. 1898

Figari, Emanuel D., Westoe Crescent, South Shields ... ... (S) Dec. 1900

Finch, Herbert K., Greyside, St. Edmund's Road, Ipswich, ...(E) { Graduate, Dec. 1888 / Member, Nov. 1894

Fish, Thomas Wilson, Lloyd's Register of Shipping, Calcutta, British India ... ...(SUR) May 1892

Fitzgerald, Durham W., Messrs. J. T. Eltringham & Co., Stone Quay, South Shields ... . (S) Dec. 1900

Fletcher, Robert, Walker Forge, Walker-on-Tyne ... ...(F M) Dec. 1886

Flohr, Justus, Director der Stettiner Maschinenbau-Actien-Gesellschaft "Vulcan," Rantstrasse 9, Stettin ... ... (E) Oct. 1886

Foley, Wm. C. le B., 3008, West Avenue, Newport News, Virginia, U.S.A. ... ... (S) { Graduate, Nov. 1887 / Member, Oct. 1892

Ford, John McLaren, 70, Mount Pleasant, Barrow-in-Furness ... (S) Nov. 1896

Forster, Alfred Lindsay, c/o Messrs. Clark, Chapman & Co., Ltd., Victoria Works, Gateshead ... ... (E) { Graduate, Nov. 1891 / Member, Oct. 1895

Foster, Henry, c/o Messrs. Patent Shaft and Axletree Co., Ltd., Wednesbury ... ... (E) April 1885

Foster, L. P., Trevillis, Liskeard, Cornwall ... ... (E) { Graduate, Nov. 1893 / Member, Oct. 1898

Foster, Martin, Claremont, Norton, Stockton-on-Tees ... ... (FM) Nov. 1900

Fothergill, J. R., 1, Bathgate Terrace, West Hartlepool ... ... (C E) Mar. 1886

Fownes, Henry, 6, Osborne Road, Jesmond, Newcastle-upon-Tyne (F M) Nov. 1884

Fox, Carter, 7, Coxon Street, Sunderland, ... (E) { Graduate, Feb. 1898 / Member, Dec. 1899

Fox, Samson, Messrs. The Leeds Forge Co., Leeds (*Life Member*) (E) Dec. 1887

Fox, William, 9, Winfield Terrace, Chester Road, Manchester ... (E) April 1895

France, Alfred Brown, 12, Bright Street, Middlesbrough ... (E) Feb. 1900

Franki, J. P., c/o Messrs. Morts Dry Dock and Engineering Co., Sydney, N.S.W., Australia ... ... (E) Jan. 1886

Fraser, John Holt, c/o Messrs. A. & R. Brown & Co., 90, Regent Road, Liverpool ... ... (E) { Graduate, Oct. 1895 / Member, Jan. 1898

Fraser, Thomas S., 12, Edinburgh Road, Armley, Leeds ... ... (E E) Jan. 1894

Friederichs, Herbert F., 1, Stanhope Avenue, West Hartlepool (EE) March 1901

Fuller, Philip S., 189, Cardigan Terrace, Gateshead-on-Tyne ... (E) Nov. 1899

Furneaux, J. B., Victoria Engine Works, Gateshead-on-Tyne ... (E) Nov. 1885

G.

Gaine, Roger L., Hartlepool Engine Works, Hartlepool (E) { Graduate, Dec. 1887 / Member, Oct. 1894

Gannaway, H. G., 7, Oxford Terrace, Renfrew, N.B. ... ... (S) Nov 1884

Garelli, Fabio, c/o Messrs. Odero fu Alessº, Sestri-Ponente, Italy (S) Oct. 1896

Garmey, John, Prince Line, Ltd., Produce Exchange, New York ... (E) Dec. 1898

ELECTED.

Garthwaite, John R., c/o Messrs. R. Ropner & Sons, Stockton-on-Tees (S) May 1889
Gates, George, Walworth Terrace, Park Road, West Hartlepool ... (E) Jan. 1899
Gayner, Robt. H., Jun., Beech Holm, Sunderland ... (E) Graduate, Mar. 1886; Member, Oct. 1888
Gearing, Ernest George, Penshurst, Clarence Drive, Harrogate ... (E) Dec. 1892
Geddes, Christopher, 2A, Drury Lane, Water Street, Liverpool ... (E) Oct. 1888
Giacomuzzi, Virgilio, c/o Messrs. Nicolo Odero fu Alessandro, Sestri Ponenti, Italy ... ... (N A) Nov. 1899
Gibson, H., 162, Roker Avenue, Monkwearmouth, Sunderland ... (S) Nov. 1884
Gibson, J. Hamilton, c/o Messrs. Laird Bros., Birkenhead Iron Works, Birkenhead ... ...(E) Graduate, April 1891; Member, Oct. 1894
Gibson, William Wright, 162, Roker Avenue, Sunderland ... (S) Nov. 1900
Gibson, Thomas, 87, Pendevad Street, Cardiff ... (E) Graduate, Nov. 1893; Member, Dec. 1897
Gibson, W. H., 37, Tatham Street, Sunderland ... ... (E) Nov. 1884
Golledge, William, c/o Messrs. Aublet, Harry & Co., 53, Curtain Road, London, E.C. ... ... (E E) Graduate, Nov. 1891; Member, Nov. 1896
Good, Farrant, c/o Messrs. Bute Dry Dock Co., Ltd., Roath Basin, Cardiff ... ... (E) Mar. 1896
Gordon, William James, c/o Messrs. Vickers, Sons & Maxim, Naval Construction Works, Barrow-in-Furness ... ... (E) Oct. 1887
Gordon, William Leslie, Invermark, Broughty Ferry, N.B. ... (E) April 1893
Graham, James Thos., 126, Westmorland Road, Newcastle-upon-Tyne ... ... (E) Nov. 1897
Graham, William, c/o Messrs. Osbourne, Graham & Co., Hylton, near Sunderland ... ... (S) Nov. 1884
Graham, William, West House, Tynemouth ... ... (S) Oct. 1891
Graham, William, 30, Hill Street, Jarrow-on-Tyne ... ... (S) April 1893
Graham, William, Rockcliffe, Redbrink Crescent, Barry Island, South Wales ... ... (E) Nov. 1894
Gravell, John, Bureau Veritas Register of Shipping, 155, Fenchurch Street, London, E.C. ... ... (N A SUR) Nov. 1884
Gray, A., 1, South Parade, Newcastle-upon-Tyne ... ... (E) Nov. 1888
Gray, George, 3, Cedars Crescent, Ryhope Road, Sunderland ... (E) Feb. 1888
Green, J. W., 3, Shaftesbury Place, Gateshead-on-Tyne ... (I & S M) May 1901
Green, W. G., Churchill Street, Willington Quay-on-Tyne ... (E) Nov. 1884
Griffith, Edwin, Messrs. The Wallsend Slipway and Engineering Co., Wallsend-on-Tyne ... ... (E) Nov. 1897
Grimes, Thomas Benjamin, 39, Vespasian Avenue, South Shields... (E) Mar. 1890
Gulston, A., Clayton Park Lodge, Jesmond, Newcastle-upon-Tyne (E) Dec. 1888
Gunn, Sir John, Chairman, Messrs. Mount Stuart Dry Docks Co., Cardiff (*Life Member*) ... ... June 1896

H.

Hall, Edward, 68, Grange Road West, Jarrow-on-Tyne ... ... (S) Nov. 1885
Hall, J. Percy, Carville, Lawrie Park Road, Sydenham, London, S.E. (E) Oct. 1885
Hall, John, 54, Westoe Parade, South Shields ... ... (E) May 1900
Hall, Thomas, 29, Selbourne Road, Ilford, London, E. ... ... (E) Nov. 1899
Hallowell, William, Woodland Road, Handsworth, Birmingham... (E) Feb. 1899
Hamilton, Andrew, 19, James Street, Liverpool ... ... (C E) April 1901

ELECTED.

Hamilton, Robert C., The College, Durham... ... (E) { Graduate, Dec. 1892 / Member, Oct. 1895

Hammar, Hugo G., Lindholmens, Verkstads Alstieholag, Göteberg, Sweden ... ... (S) Nov. 1890

Hammersley, B. J., 47, Kingsley Terrace, Newcastle-upon-Tyne .. (E) May 1901

Haramüshi, M., Jun., Mitsu Bishi Dockyard and Engine Works, Nagasaki, Japan ... ... (N A) Nov. 1897

Harbottle, John, Wh.Sch., 3, Vernon Parade, Gateshead-on-Tyne (E) Oct. 1896

Harbottle, Thomas, 5, Alexander Terrace, Newcastle-upon-Tyne (E) Jan. 1900

Hardy, Henry Thomas, 10, The Retreat, Sunderland ... ... (S) Dec. 1899

Harkness, Richard, Grange Road, West Hartlepool ... (S SUR) Nov. 1884

Harlow, F., 8, Benton Terrace, Newcastle-upon-Tyne ... ... (E) Nov. 1884

Harman, Bruce, Messrs. The Linde British Refrigerating Co., 35, Queen Victoria Street, London, E.C. ... ... (E) Oct. 1886

Harper, J. H., 1, Beaumont Street, North Shields ... ... (E) Jan. 1885

Harris, Anthony. 73, Queen Victoria Street, London, E.C. ... (E) Mar. 1892

Harrison, Alfred, c/o Messrs. Richardsons, Westgarth & Co., Scotia Engine Works, Sunderland (*Life Member*) ... (E) Oct. 1889

Harrold, Alexander, 26, Park Road, Newcastle-upon-Tyne ... (E) Nov. 1884

Harrold, F., 30, Park Road, Newcastle-upon-Tyne ... ... (E) Nov. 1888

Harroway, George Mitchell, 18, West Terrace, North Ormesbey, Middlesbrough ... ... (S) Jan. 1896

Hartley, W. A., c/o Messrs. Charles Cammell & Co., Cyclops Works, Sheffield ... ... (E) Jan. 1898

Harvey, Herbert Buchanan, Cambridge Electric Supply Co., Thompson's Lane, Cambridge ... ... (E) { Graduate, Jan. 1896 / Member, Oct. 1898

Harvey, James Andrew, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (E) Feb. 1899

Harvey, John W. J., 1, Richmond Villa, Chertsey Road, Redland, Bristol ... ... (E) Feb. 1889

Haswell, Wm. Spence, c/o Messrs. Tangye, Ltd., 3, St. Nicholas Buildings, Newcastle-upon-Tyne ... ... (E) Oct. 1900

Haussman, B., 39A, Gracechurch Street, London. E.C. ... ... (E) Feb. 1899

Head, William, Hawthorn House, Hook Road, Goole ... ... (S) Feb. 1901

Headlam, Robert, New Park Terrace, Hartburn Lane, Stockton-on-Tees ... ... (E) Nov. 1886

Heaviside, Arthur West, 7, Grafton Road, Whitley Bay, Northumberland ... ... (E E) Oct. 1896

Heck, John H., Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (S SUR) Nov. 1885

Henderson, Alex., c/o Messrs. Empreza, Nacional, De. Nav. D'Vapor, Lisbon ... ... (E) April 1893

Henderson, A. M., 3, Greatham Terrace, West Hartlepool ... (E) Nov. 1890

Henderson, George, 54, Westmorland Road, Newcastle-upon-Tyne ... ... (E) Nov. 1884

Henderson, John, 96 Plasturton Avenue, Canton, Cardiff ... ... (E) June 1896

Henry, William P., Cragside, St. Aidan's Road, South Shields ... (E) April 1897

Henshall, Samuel, c/o Messrs. Sir Raylton Dixon & Co., Middlesbrough ... ... (S) { Graduate, May 1885 / Member, Jan. 1894

Hepburn, Alfred, c/o Messrs. N.E. Marine Engineering Co., Northumberland Forge, Wallsend-on-Tyne ... ... (F M) Dec. 1890

Hesketh, Thomas, Bryn Tirion, Richmond Road, Cardiff ... ...(SUR) April 1896

ELECTED.

Heslop, Thomas, 6, Eldon Place, Newcastle-upon-Tyne ... ... (E) Dec. 1900
Hetherington, William, 27, Co-operative Terrace, Sunderland ... (S) Dec. 1899
Hewison, Herbert, 9, Mainsforth Terrace West, Sunderland ... (S) Dec. 1900
Higginbotham, George Emerton, Glenthorn, Midhurst Road, Benton, Newcastle-upon-Tyne ... ... (S) Nov. 1900
Higgins, C. F., c/o Messrs. T. Richardsons, Westgarth & Co., Hartlepool Engine Works, Hartlepool... ... ... (E E) Feb. 1898
Hildrey, A. J., 11, Newcastle Road, Sunderland ... ... (S) Nov. 1884
Hill, Maxwell, 7, The Side, Newcastle-upon-Tyne ... ... (N A) Nov. 1884
Hinchliffe, Robert, 25, Hawthorn Street, Newcastle-upon-Tyne ... ... (S) { Graduate, Nov. 1893 / Member, Oct. 1898
Hirst, Richard, 25, Brougham Terrace, West Hartlepool ... (E SUR) Nov. 1885
Hodge, Rowland F. W., c/o Messrs. The Northumberland Shipbuilding Co., Limited, Northumberland Shipyard, Howdon-on-Tyne ... ... (S) Dec. 1890
Hogarth, G. V., 32, Water Lane, Maryland Point, London, E.C. (S) May 1900
Hogg, Archibald, Welbeck Road, Walker-on-Tyne ... ... (S) Jan. 1897
Hogg, James, 8, Lovaine Terrace, North Shields ... ... (B F) Nov. 1889
Hök, Wilhelm, 10, Engelbrektogatatan, Stockholm ... ... (S) Oct. 1886
Holgate, Charles H., School Close Works, Leeds ... ... (E) Feb. 1895
Hollis, Henry E., 40 Union Street, Glasgow ... ... (I & S M) Feb. 1885
Holmes, John H., Wellburn, Jesmond Dene Road, Newcastle-upon-Tyne ... ... (E E) Jan. 1888
Homji, A. C. N. ... ... (E) Nov. 1884
Hougland, Even, Lloyd's Surveyor, Bergen, Norway ... ... (E) Dec. 1896
Houston, John, 7 Thornhill Crescent, Sunderland ... ... (E) Nov. 1894
Hughes, Thos. Charles, 3, Summerhill Street, Newcastle-upon-Tyne ... ... (E) { Graduate, Nov. 1893 / Member, Nov. 1897
Hunt, Allan E., 11, St. Cuthbert's Terrace, Bensham, Gateshead (SUR) Feb. 1901
Hunter, George B., Messrs. C. S. Swan, Hunter & Co., Wallsend-on-Tyne ... ... (S) Nov. 1884
Hunter, George Ernest, Aykleyheads, Durham ... (S) { Graduate, Feb. 1898 / Member, Nov. 1899
Hunter, Joseph Gilbert, Lloyds Register of Shipping, Newport News, Va., U.S.A. ... ... (SUR) Feb. 1900
Hunter, J. W., 10, Princess Street, Stockton Road, Sunderland ... (E) May 1885
Hunter, Summers, c/o Messrs. N.E. Marine Engineering Co., Northumberland Engine Works, Wallsend-on-Tyne ... ... (E) Nov. 1885
Hutchinson, C. W., 6, Park Parade, Westmorland Road, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Hutchinson, Wesley, B.A., 4, High Street, Newton Heath, Manchester ... ... (E) Oct. 1891
Hutchison, J., Board of Trade Offices, Middlesbrough ... ...(SUR) Dec. 1891
Hyslop, Alfred M., c/o Messrs. Boothroyd, Hyslop & Co., Akenside Street, Bootle, Liverpool ... ... (E) Mar. 1900

I.

Inglis, John, c/o Messrs. Hawthorn & Co., Leith ... ... (S) April 1887
Inglis, John, Pointhouse Shipyard, Partick, Glasgow ... (E & S) Oct. 1886
Irvin, Matthew B., Government Arsenal, Alexandria, Egypt ... (E) Oct. 1900
Irwin, J. H., c/o Messrs. N.E. Marine Engineering Co., Sunderland Engine Works, South Docks, Sunderland ... ... (E) Nov. 1884

ELECTED.

Ito, Kumezo, Mitsu Bishi Dockyard and Engine Works, Nagasaki, Japan ... ... (E) Dec. 1900

Ives, Bernard, c/o Messrs. Lloyd's Register of Shipping, 8, White Lion Court, Cornhill, London, E.C. ... ... (S) Feb. 1898

J.

Jack, Charles Kellie, c/o Messrs. Ropner & Sons, Shipbuilders, Stockton-on-Tees ... ... (S) Nov. 1897

Jack, William C., c/o Messrs. The Hong Kong & Whampoa Dock Co., Limited, Hong Kong, China ... ... (E) Nov. 1894

Jackson, Albert S., 3, Mount Stuart Square, Cardiff ... ... (E) Mar. 1896

Jackson, William S., Messrs. Gourlay Bros. & Co., Camperdown Shipyard, Dundee... ... ... (S) April 1891

James, M. C., 6, Park Terrace, Gateshead-on-Tyne ... ... (S) Nov. 1884

Jarvis, H. Robert, 6, Dene View, Wallsend-on-Tyne ... ... (S) Feb. 1901

Jennings, Frederick W., c/o Messrs. Sturtevant Engineering Co., Limited, 147 Queen Victoria Street, London, E.C. ... ... (E) Feb. 1898

Jobling, W. J., 1, Akenside Hill, Newcastle-upon-Tyne ... (E & S O) Nov. 1884

Jobson, Robert, Jun., Clifton Avenue, West Hartlepool ... ... (S) Feb. 1898

Johnson, Alexander A., Bank Chambers, Sandhill, Newcastle-upon-Tyne ... ... (E) Feb. 1893

Johnson, Johan, 7, Vestra Hamngaten, Gothenburg, Sweden ... (S) May 1885

Johnson, Joseph, 7, Dean Street, Newcastle-upon-Tyne ... (E) May 1901

Johnson, T. Allan, 64, Cathedral Road, Cardiff ... ... (S) Nov. 1884

Johnstone, William, Lloyd's Register of Shipping, 14, Cross-shore Street, Greenock ... ...(SUR) Nov. 1884

Jones, George, c/o Messrs. W. Gray & Co., Shipyard, West Hartlepool ... ... (S) Oct. 1888

Jubb, Arthur, 29, Coldwell Terrace, Felling-on-Tyne ... ... (E) Jan. 1900

K.

Keene, H. R., Lloyd's Register of Shipping, Ouest Quai, 28, Katendyk, Antwerp ... ... (E) { Graduate, May 1885 / Member, April 1887

Kendall, Stonard O., Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London, E.C. ... ...(SUR) Mar. 1891

Kennedy, William, 14, Gladstone Street, Hartlepool ... ... (E) April 1900

Kerfoot, James, Rue Osy, 20, Antwerp ... ... (E) Oct. 1892

King, John, Surveyor's Office, Board of Trade, Liverpool ... ... (S) { Graduate, Dec. 1890 / Member, Oct. 1892

Kirby, John Storne, 8, Myrtle Crescent, Westoe Lane, South Shields ... ... (E) Mar. 1899

Kirkaldy, John, 21, Ground Floor, Leadenhall House, 101, Leadenhall Street, London, E.C. ... ... (E) Nov. 1885

Kitching, J. F., Clifton Avenue, West Hartlepool ... ... (E) Nov. 1890

Kyle, Norman M. W., 26, Sandhill, Newcastle-upon-Tyne ... (E) Nov. 1898

L.

Lace, Basil T., Lyncombe Rise, Bath ... ... (E) { Graduate, Nov. 1895 / Member, Nov. 1897

Laing, Andrew, c/o Messrs. Wallsend Slipway and Engineering Co., Wallsend-on-Tyne ... ... (E) Oct. 1892

Laing, Hugh, Deptford Shipyard, Sunderland ... ... (N A) April 1897

ELECTED.

Laing, John, c/o Messrs. R. & W. Hawthorn, Leslie, & Co., St. Peter's, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Landreth, Cowen, 34, Simonside Terrace, Newcastle-upon-Tyne ... (E) Mar. 1896
Lang, William Veysey, c/o Messrs. Watts, Watts & Co., London... (E) Nov. 1897
Larkin, James, Tyne View, East Jarrow-on-Tyne ... ... (E) Nov. 1884
Leathard, Thomas Surtees, 9, Otto Terrace, Sunderland ... ...(SUR) April 1899
Lewins, Frank, 23, Meldon Terrace, Heaton, Newcastle-upon-Tyne (E) Dec. 1895
Lewis, R. A., Newburn Steel Works, Newburn-on-Tyne ... ... (E) Nov. 1884
Liddell, J., c/o Messrs. W. Denny & Bros., Engine Works, Dumbarton (E) Nov. 1884
Lie, Gotfred, Det Bergenske Dampskibsselskab, Bergen ... ... (E) Jan. 1895
Lindfors, Hugo, Surveyor to Lloyd's Register of Shipping, 16, Alexandersgatan, Helsingfors, Finland ... ... (SUR) May 1889
Lineham, Wilfrid J., Jesmond, Leyland Road, Lee, London, S.E. (E) Oct. 1890
Link, Rolls Percival, 81, Southwark Street, London, S.E.... ... (CE) Mar. 1901
Lishman, John J., Jun., 16, Lovaine Place, North Shields ... ... (E) { Graduate, Dec. 1892 / Member, May 1900
Littleboy, Chas. Wm., The Woodlands, Saltburn-by-the-Sea ... (S) Oct. 1887
Littledale, John W. E., 11, Akenside Terrace, Jesmond Road, Newcastle-upon-Tyne ... ... (E) May 1896
Livingston, Thos. L., Dunedin House, Jarrow-on-Tyne ... ... (S) Nov. 1884
Lohmeyer, H., 53, Crown Street, Newcastle-upon-Tyne ... ... (E) Nov. 1884
London, William Jas. Albert, c/o Messrs. Brown, Boveri, & Co., Ltd., Baden, Switzerland ... ... (E) { Graduate, May 1898 / Member, May 1901
Long, A. E., 124, Albert Road, Jarrow-on-Tyne ... ... (S) Nov. 1884
Loveridge, Wm. Henry, York Road, West Hartlepool ... ... (E) Feb. 1901
Lowdon, David, Messrs. The Barry Graving Dock and Engineering Co., Limited, Barry Dock, near Cardiff ... ... (E) May 1894
Lowdon, John, Messrs. The Barry Graving Dock and Engineering Co., Limited, Barry Dock, near Cardiff ... ... (E) Dec. 1891
Lumley, William, 2, Claremont, Gateshead-on-Tyne... (E { Graduate, June 1896 / Member, Oct. 1898
Lund, Pearson, Messrs. Noble & Lund, Northern Machine Tool Works, Felling-on-Tyne ... ... (E) Nov. 1900

M.

MacColl, Hector, Bloomfield, Belfast ... ... (E) Dec. 1890
MacColl, Hugo, Wreath Quay Engineering Works, Sunderland (*Life Member*) ... ... (E) Nov. 1896
Maccoy, John, Springfield, Gateshead-on-Tyne ... ... (E) Feb. 1886
Macdonald, Charles, 4, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ...(SUR) Feb. 1898
MacDonald, David R., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Newcastle-upon-Tyne (S) Nov. 1891
Macdonald, John C., c/o Messrs. N.E. Marine Engineering Co., Northumberland Engine Works, Wallsend-on-Tyne ... ... (E) Nov. 1899
Mace, W., 253, Albert Road, Jarrow-on-Tyne ... ... (E) Jan. 1886
MacHaffie, John, 635, Terrace Place, Schenectady, New York, U.S.A. (E) Dec. 1885
Macgregor, W. L., Board of Trade Surveyors' Offices, Blyth ...(SUR) Mar. 1899
Mackay, William, 15, Camperdown Road. Scotstoun, Renfrewshire ... ... (S) Mar. 1892
Mackley, Edward N., 97, Enfield Road, Elswick, Newcastle-upon-Tyne... ... ... (E) April 1901

ELECTED.

Mail, M., Jun., c/o Messrs. Middle Dock and Engineering Co., South Shields ... ... (E) Nov. 1897
Mair, James, Wh.Sc., 39, Inverleith Row, Edinburgh ... ... (E) Oct. 1894
Manaira, Guiseppe, 4, Salita S Gerslamo, Genoa, Italy ... (E & N A) Nov. 1893
Manning, Henry Lewis, Sea View, Ryhope, Sunderland ... ... (E) Dec. 1900
Marr, James, c/o Messrs. J. L. Thompson & Sons, North Sands Shipyard, Sunderland ... ... (S) Nov. 1884
Marsden, John H. Wade, 9, Lovaine Crescent, Newcastle-upon-Tyne ... ... (E) Nov. 1899
Marshall, F. C., Akenside Lodge, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Marshall, Frank T., Messrs. R. & W. Hawthorn, Leslie & Co., St. Peter's, Newcastle-upon-Tyne ... ... (E) { Graduate, Jan. 1885 / Member, Oct. 1888
Marshall, R. J., 53, Larkspur Terrace, Jesmond, Newcastle-upon-Tyne... ... ... (E) Mar. 1887
Marshall, Robert. 12, Broughton Road, South Shields ... ...(SUR) Mar. 1901
Maslen, Frank E., The Priory, Hampstead Heath, London, N.W. ... ... (E) { Graduate, Nov. 1891 / Member, May 1898
Mason, George F., Lloyds' Bank Buildings, Mount Stuart Square, Cardiff ... ... (E) Oct. 1895
Mather, Charles, 2, St. George's Terrace, Newcastle-upon-Tyne... (SUR) Oct. 1888
Mather, Clifford Basil, Lesbury House, Lesbury, R.S.O. (N A) { Graduate, Oct. 1892 / Member, Oct. 1898
Mather, Thomas Brewer, 13, Park Avenue, Whitley Bay, Northumberland ... ... (C E) Nov. 1898
Matheson, William, c/o Messrs. R. & W. Hawthorn, Leslie & Co., Hebburn-on-Tyne... ... ... (S) Dec 1889
Mathieson, Donald, 30, Jackson Street, Sunderland ... ... (E) Nov. 1898
Matthews, A., c/o Messrs. Blyth Shipbuilding Co., Blyth... ... (S) Nov. 1884
Matthews, Jas., c/o Messrs. R. & W. Hawthorn, Leslie & Co., Forth Banks, Newcastle-upon-Tyne ... ... (E) Oct. 1886
Maughan, Philip A., 8, Ashleigh Grove, West Jesmond, Newcastle-upon-Tyne ... ... (S) Dec. 1900
Maxwell, Thomas, 15, Ashfield Terrace, East, Newcastle-upon-Tyne ... ... (E) Nov. 1899
Maxwell, William Ward, B.Sc., Messrs. H. Charlton & Co., Engineers, Gateshead-on-Tyne ... ... (E) Dec. 1896
McBride, William, 8, Beaconsfield Street, Hartlepool ... ... (E) Dec. 1894
McDonald, John, 9, York Street, Glasgow ... ... (E) Dec. 1900
McGillivray, Peter, 14, Normanton Terrace, Newcastle-upon-Tyne (E) Nov. 1899
McGlashan, Arch., Beechcroft, Clifton Avenue, West Hartlepool (S) Nov. 1885
McGregor, Duncan, 5, Bishopton Street, Sunderland ... ... (S) Dec. 1899
McIlvenna, J. G., c/o Messrs. The Tyne Pontoons and Dry Docks Co., Wallsend-on-Tyne ... ... (S) Nov. 1884
McKechnie, James, Messrs. Vickers, Sons & Maxim, Naval Construction Works, Barrow-in-Furness ... ... (E) April 1896
McKenna, Francis, c/o Messrs. E. F. Wailes & Co., 4, St. Nicholas' Buildings, Newcastle-upon-Tyne ... (E) { Graduate, Dec. 1890 / Member, Dec. 1896
McLaren, Robert M., Lloyd's Register of Shipping, 3, St. Nicholas Buildings, Newcastle-upon-Tyne ... ... (S) Nov. 1893
McLaren, William, 16, Rock Park, Rock Ferry, Cheshire ... ... (E) Oct. 1894
McLean, John H. K., Abey House, Plotina Terrace, South Shields (S) Mar. 1897

ELECTED.

McNeil, Thomas Young, Ship Drawing Office, Messrs. John Brown & Co., Clydebank, Glasgow ... ... (S) Oct. 1895

McRae, Thomas, 16, Western Hill, Sunderland ... ... (S) Dec. 1900

Meagher, H. L., 4, Linden Terrace, Newcastle-upon-Tyne ... ... (E) Dec. 1896

Mechan, Henry, Scotstoun Ironworks, Scotstoun, Glasgow ... (E) May 1898

Meldrum, Michael, Humbledon View, Sunderland ... ... (E) Dec. 1893

Mellanby, Alex. Lawson, B.Sc., 8, Park Avenue, Chorlton-cum-Hardy, Manchester ... ... (E) { Graduate, Dec. 1894 / Member, Oct. 1896

Messenger, Thomas, "Greeba," Matham Road, East Molesey, Surrey ... ... (E) Mar. 1887

Metcalf, Thos., 18, John Street, Sunderland ... ... (S) { Graduate, May 1885 / Member, Nov. 1893

Metcalfe, C. S., 24, Croft Avenue, Sunderland ... ... (E) Nov. 1884

Meuwissen, J., 18, Esplanade, Whitley Bay, Northumberland ... (E) Nov. 1899

Micheli, Pietro, Jun., Via Sottoripu, No. 1, piano nobile, Genoa, Italy ... ... (E & N A) Oct. 1888

Middlemass, Thomas, 3, Albert Place, Norton Road, Stockton-on-Tees ... ... (S) Oct. 1889

Middleton, H., 20, Lynnwood Avenue, Newcastle-upon-Tyne (I & S M) Jan. 1893

Middleton, Robert Alexander, c/o Messrs. Northumberland Shipbuilding Co., Howdon-on-Tyne ... ... (N A) Oct. 1892

Millar, Thos., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Walker-on-Tyne ... ... (S) Nov. 1884

Milton, James Edward, Messrs. Lloyd's Register of Shipping, 3, St. Nicholas Buildings, Newcastle-upon-Tyne ... ...(SUR) Nov. 1900

Milton, J. T., Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London, E.C. ... ... (E SUR) Nov. 1886

Mitchell, Wm., Glen Street, Hebburn-on-Tyne ... (S) { Graduate, Jan. 1898 / Member, Feb. 1901

Moffatt, James, 7, Murray's Terrace, Belfast, Ireland (E) { Graduate, Dec. 1889 / Member, Oct. 1892

Moffatt, William Graham, 44, Lennox Avenue, Scotstoun, Glasgow (E) Mar. 1899

Moffitt, George, c/o Messrs. The Blyth Shipbuilding Co., Blyth ... (S) Oct. 1888

Moffoot, Alexander, 32, Eldon Street, Chester Road, Sunderland.. (S) Mar. 1898

Moncrieff, John M., 2, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (C E) Dec. 1899

Moody, Thomas V., c/o Messrs. Scott Bros., 46, Sandhill, Newcastle-upon-Tyne ... ... (E) Dec. 1887

Moore, Wm. Henry, c/o Messrs. Workman, Clark, & Co., Engine Works, Spencer Basin, Belfast ... ... (E) Nov. 1897

Morgan, John Osborn, Bank Chambers, Sandhill, Newcastle-upon-Tyne ... ... (CE) Feb. 1901

Morgan, W. H., 22, Rochdale Street, Wallsend-on-Tyne ... ... (E) Nov. 1884

Morison, D. B., Hartlepool Engine Works, Hartlepool ... ... (E) Feb. 1885

Mörk, Peter, 31, Holsteinsgude, Copenhagen ... ... (E) Nov. 1884

Moroney, E. F., 11, Shields Road, East, Newcastle-upon-Tyne ... ... (E) { Graduate, Feb. 1892 / Member, Nov. 1899

Morrison, Robt., Highfield, St. Aidan's Road, South Shields ... (E) Nov. 1886

Morrison, William, Lloyd's Register of Shipping, Maritime Buildings, Dundee ... ... (E SUR) Oct. 1890

Morton, Richard Fraser, Lloyd's Register of Shipping, 24, George Street, Sheffield ... ... (E SUR) Oct. 1890

ELECTED.

Mould, Francis H., 37, Hawthorn Road, Gosforth, Newcastle-upon-Tyne ... ... (E) { Graduate, Feb. 1892 / Member, Jan. 1897

Mountain, William Chas., Messrs. Ernest Scott, Mountain, & Co., Close, Newcastle-upon-Tyne ... ... (E E) Feb. 1889

Muir, Alfred Edward, Messrs. J. L. Thompson & Sons, North Sands Shipyard, Sunderland ... ... (S) Mar. 1893

Muir, Chas. M., 32, William Street, Newcastle Road, Sunderland... (S) May 1899

Muir, Robert, 11, Clarence Crescent, Whitley Bay, Northumberland ... ...(SUR) Oct. 1886

Muir, Robert Home, 1, Lovaine Crescent, Newcastle-upon-Tyne ... (S) Oct. 1892

Munck, Ove. Holger, c/o Messrs. Burmeister & Wain, Shipbuilders, Copenhagen, Denmark ... ... (S) Feb. 1899

Munro, James, c/o Messrs. Hawthorn, Leslie, & Co., Hebburn-on-Tyne... ... ... (E) Mar. 1901

Murray, Charles W., c/o Messrs. Babcock & Wilcox, Ltd., Ogle House, Farringdon Street, London, E.C. ... ... (E) May 1901

Musgrave, Evers, 8, Lastingham Terrace, Frilford, York (E) { Graduate, Nov. 1891 / Member, Oct. 1895

Myles, David, c/o Messrs. N.E. Marine Engineering Co., Northumberland Engine Works, Wallsend-on-Tyne ... ... (E) Nov. 1884

N.

Nastoupil, John, Chief Engineer, Austro-Hungarian Navy, Marine Casino, Pola, Austria ... ... (E) Nov. 1890

Neill, William Reid, 15, Salem Hill South, Sunderland ... ... (E) Dec. 1897

Nevins, William, 1, Hall Royd, Shipley, Yorkshire ... ... (E) Mar. 1894

Nevison, Thomas C., 18 Milton Road, West Hartlepool ... ... (E) April 1900

Nicholls, H. E., 25, Churchill Street, Sunderland ... ... (E) Nov. 1893

Nichols, Walter W., 30, Denmark Street, Gateshead-on-Tyne ... (E) May 1895

Nicholson, P. F., c/o Messrs. R. & W. Hawthorn, Leslie, & Co., Hebburn-on-Tyne... ... ... (S) Feb. 1901

Nicholson, John S., North View, Mowbray Road, Westoe, South Shields ... ... (E) Nov. 1893

Nicholson, Joseph Cook, Collingwood Street, Newcastle-upon-Tyne (E) Feb. 1897

Nicholson, Thos. Head, 90, Rye Hill, Newcastle-upon-Tyne ... (E) Nov. 1897

Nicol, John M., 15, Linskill Terrace, North Shields ... ... (E) Nov. 1884

Nicolson, G. C., c/o Messrs. R. & W. Hawthorn, Leslie, & Co., St. Peter's, Newcastle-upon-Tyne ... ... (E) { Graduate, Oct. 1885 / Member, Oct. 1888

Niven, William A., 6, Jackson Street, Walker-on-Tyne ... ... (E) Nov. 1898

Noble, Harry, Northern Machine Tool Works, Brewery Lane, Felling-on-Tyne .. .. (E) Nov. 1888

Nodder, Joseph, Ash Lea, Crabtree, Sheffield ... ... (F M) May 1893

Norman, W. S., Orchard House, Whitby, near Chester ... ... (E) Nov. 1884

Norton, Harold P., U.S.S. "Albany," c/o Senr. Squadron Commander, U.S. Naval Forces, Cavite, P.I. ... ... (E) Oct. 1890

Noton, F. R., Lloyd's Register of Shipping, 342, Argyle Street, Glasgow ... ... (S) Nov. 1884

Nunes, Enrique E., 1898, Calle Virreyes, Belgrano, Buenos Ayres (E) April 1891

O.

Oliver, John Wm., 31, Baring Street, South Shields ... ... (E) Dec. 1900

O'Neil, J. J., 2, Erith Terrace, Sunderland ... ... (E) Nov. 1884

ELECTED.

Ord, Godfrey C., 4, The Esplanade, Sunderland ... ...(E E) Jan. 1897
Orde, E. L., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Newcastle-upon-Tyne ... ... (E) Oct. 1887
Orlando, Chev. Giuseppe, Cantiere Navale, Fratelli Orlando, Leghorn ... ... (N A) Jan. 1893
Ormonde, John Grey, 35, Percy Gardens, Tynemouth ... ... (E) Nov. 1897
Orr, John, B.Sc., Lecturer in Engineering, South African School of Mines, Kimberley, S.A. ... ... (E) Mar. 1897
Ortton, Alfred R., 27, General Graham Street, Chester Road, Sunderland ... ... (E) Nov. 1898
Ostens, Joseph, 4, Jackson Street, North Shields ... . (S) Nov. 1900
Owens, J. Switzer, B.A., Carleys Bridge House, Enniscorthy, Ireland ... ... (E) Oct. 1898
Oxley, G., 51, Norman Terrace, Howdon-on-Tyne ... ... (S) Nov. 1884
Oxton, Walter, 96, Blackpool Street, Burton-on-Trent (E) { Graduate, Dec. 1890 / Member, May 1894

P.

Paget, John W., Roker Villa, Park View, Heaton, Newcastle-upon-Tyne ... ... (S) Dec. 1900
Parker, James H., Gladstone Street, Hartlepool ... ... (E) April 1900
Parr, Joseph E., 21, Zion Terrace, Newcastle Road, Sunderland... ... ... (S) { Graduate Nov. 1898 / Member, Dec. 1899
Parsons, Hon. Charles A., Turbinia Works, Wallsend-on-Tyne ... (E E) Dec. 1887
Parsons, Harry F., Lindenhurst, Clarence Road, Teddington, Middlesex ... ... (E) Dec. 1890
Pascoe, J. R., Tyrmont, Woodford Green, Essex (*Life Member*) ... (S) Dec. 1889
Patterson, Jas., c/o Messrs. Caldwell & Co., Limited, Elliot Street, Glasgow ... ... (E) Nov. 1884
Pattison, Jos., Bute Docks, Cardiff ... ... (E) Nov. 1884
Paulin, William J., 24, Oxford Street, Newcastle-upon-Tyne ... (E) April 1897
Paulson, John, c/o Messrs. William Cramp & Sons, Shipbuilders, Philadelphia, Pa., U.S.A.... ... ... (S) Feb. 1886
Paxton, John F., 52, Walker Terrace North, Gateshead ... ... (E) May, 1899
Pearson, James T., 10, Beech Grove Road, Newcastle-upon-Tyne ... ... (S) { Graduate, Nov. 1893 / Member, Dec. 1897
Penney, R. H., Board of Trade Offices, 79, Mark Lane, London, E.C. ... ... (S SUR) Nov. 1884
Pepper, W., 9, West Villas, Oxbridge Lane, Stockton-on-Tees ... (E) Nov. 1888
Perrett, Jos. Richard, West View, Durham Road, Gateshead-on-Tyne ... ... (N A) Nov. 1897
Pescod, Joseph Hind, 1, Railway Street, Jarrow-on-Tyne (S) { Graduate, Feb. 1898 / Member, Jan. 1900
Petersen, John L., Havelock House, Victoria Road, West Hartlepool (SUR) Oct. 1888
Petree, James, Lloyd's Register of Shipping, 12, Oriel Chambers, Water Street, Liverpool ... ... (N A SUR) Oct. 1885
Petterson, Carl Edwin, 7, Vestra Hamngaten, Gothenburg, Sweden (E) Oct. 1891
Phayer, Robert P., 27, Edwards Road, Whitley Bay, Northumberland ... ... (S) Dec. 1900
Philipson, Roland, Tynemouth... ... ... (E) Dec. 1884
Phorson, P., Glen Lea, Roker, Sunderland ... ... (S) Nov. 1884
Piaud, Leon, c/o Messrs. Delanney, Bellville, & Co., St. Denis, France ... ... (N A) Nov. 1888

ELECTED.

Pierce, Robert Cecil, 13, Kensington Gardens Square, London, W. ... ... (E E) { Graduate Dec. 1898 / Member Dec. 1899

Pirrie, Norman, c/o Messrs. Babcock, Wilcox, & Co., Limited, 147, Queen Victoria Street, London, E.C. ... ... (E) Nov. 1897

Pitt, Frederick William, 552, Chester Road, Old Trafford, Manchester, S.W. ... ... (E SUR) Oct. 1890

Poli, Rodolfo, Chioggia, Italy ... ... (N A) Jan. 1890

Pollock, Walter, c/o Messrs. Jas. Pollock, Sons, & Co., 22, Billiter Street, London, E.C. ... ... (N A) April 1900

Potts, Cuthbert Ivan, 4, Sidney Road, Bootle, Liverpool .. ... (E) Oct. 1895

Powell, James Richard, Royal Stuart Buildings, Cardiff ... ... (C E) May 1894

Price, John, 6, Osborne Villas, Jesmond, Newcastle-upon-Tyne ... (S) Nov. 1884

Pringle, Alfred, 10, Somerset Terrace, Walker-on-Tyne (S) { Graduate, Dec. 1891 / Member, Jan. 1894

Pringle, James G., 10, Somerset Terrace, Walker-on-Tyne... ... (S) Oct. 1892

Proven, George, 358, Leith Walk, Leith, N.B. ... ... (E) Mar. 1901

Purdon, Andrew S., Messrs. Irvine's Shipbuilding and Dry Docks Co., Limited, West Hartlepool ... ... (S) Oct. 1892

Purvis, Andrew Alex., 3, Victoria Avenue, Whitley Bay, Northumberland ... ... (E) Dec. 1899

Purvis, Fred. W., c/o Messrs. Sir W. Gray & Co., Central Shipyard, West Hartlepool ... ... (S) April 1893

Putnam, T., Darlington Forge, Darlington ... ... (F M) Nov. 1884

Q.

Quicke, Herbert John, c/o Messrs. Harfield & Co., Blaydon Ironworks, Blaydon-on-Tyne ... ... (E) Feb. 1891

R.

Ramage, J. T., St. Aubyn's, Bonnington, Edinburgh ... ... (E) April 1887

Ramage, John Anderson, 74, Glen Terrace, Hebburn-on-Tyne ... (S) Oct. 1892

Ranken, David, Azalea Terrace, Sunderland ... ... (E) Nov. 1900

Readhead, Jas., Westoe Hall, South Shields ... ... (S) Nov. 1884

Readhead, John, Rockcliffe, Westoe, South Shields ... ... (E) Mar. 1886

Readhead, R., South Garth, Westoe Village, South Shields ... (E) Nov. 1884

Readhead, W. B., Beach View, South Shields .. .. (S) Nov. 1886

Reed, James, Messrs. Palmer's Shipbuilding and Iron Co., Ltd., Jarrow-on-Tyne ... ... (S) Dec. 1897

Reed, Joseph, Angerton House, North Shields ... ... (E) Oct. 1889

Reed, J. W., c/o Messrs. Palmer's Shipbuilding and Iron Co., Limited, Engine Works Department, Jarrow-on-Tyne ... (E) Nov. 1884

Reed, Richard, 12, Selby Terrace, Maryport ... ... (S) Oct. 1894

Reid, John Robert, 88, Leslie Terrace, Aberdeen ... ... (E) Nov. 1898

Reid, William, c/o Messrs. Wm. Reid & Co., 112, Fenchurch Street, London, E.C. ... ... (E) Dec. 1899

Rennoldson, C., Messrs. J. P. Rennoldson & Sons, South Shields (S) Jan. 1886

Rennoldson, Jos. M., Messrs. J. P. Rennoldson & Sons, South Shields (S) Feb. 1886

Reynolds, Charles H., c/o Messrs. Burmeister & Wain, Shipbuilders, Copenhagen, Denmark ... ... (S) Mar. 1889

Reynolds, W. G., 26, Sandhill, Newcastle-upon-Tyne ... ... (E) Oct. 1886

Richardson, Sir Thomas, B.A., Hartlepool Engine Works, Hartlepool ... ... (E) April 1888

ELECTED.

Richardson, Wigham, Wingrove House, Newcastle-upon-Tyne ... (S) Nov. 1884
Rickaby, A. A., 27, Olive Street, Sunderland ... ... (E) Mar. 1888
Ridley, J. H., Messrs. R. & W. Hawthorn, Leslie & Co., St. Peter's, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Riley, J. H., Messrs. Riley Bros., Stockton-on-Tees ... ... (B B) May 1893
Riseley, Harry Lorimer, 10, Renfrew Road, Wallsend-on-Tyne ... (E) Nov. 1900
Ritson, Maurice, Lloyd's Register of Shipping, Piazza S. Giorgio, 32, Scalaprima, Genoa ... ... (E SUR) Nov. 1884
Ritson, S. M., 7, Dogo Street Cardiff ... ... (E) Graduate, Nov. 1887; Member, Nov. 1893
Roberts, W. C., 18, Windsor Road, Forest Gate, Essex ... ... (E) Mar. 1901
Robinson, Charles O., Ingleside, North Shields ... (E) Graduate, Dec. 1893; Member, Nov. 1899
Robinson, William, Delaval House, 3, Broxbourne Terrace, Sunderland ... ... (E) Graduate, May 1885; Member, April 1888
Robson, David M., 11, Village Terrace, South Shields ... ... (E) Nov. 1899
Robson, George, 9, Wellington Terrace, South Shields ... ... (E) Oct. 1889
Robson, George, 140, Aurelian Terrace, South Shields ... ... (E) Feb. 1896
Robson, John H., 22, Eversley Place, Heaton, Newcastle-upon-Tyne (E) Nov. 1885
Robson, J. M., 4, Abbey Terrace, Gateshead-on-Tyne ... ... (E) Nov. 1884
Robson, M., 20, Tavistock Place, Sunderland ... ... (S) Nov. 1884
Robson, Nathaniel E., 15, Laburnum Avenue, Wallsend-on-Tyne ... ... (E) Graduate, Dec. 1894; Member, Nov. 1897
Robson, Robert, 5, St. Mary's Place, Newcastle-uponTyne (EE) Graduate, Dec. 1894; Member, March 1901
Roger, Robert, Stockton Iron Foundry, West Row, Stockton-on-Tees (E) Nov. 1888
Rogers, Herbert M., Redcliffe, Durham Avenue, Bromley, Kent (SUR) April 1889
Rolf, George, 8, Bentinck Crescent, Newcastle-upon-Tyne ... (E E) May 1892
Rolland, Alexander, Villa Ruzic, Susak, Fiume, Hungary ... ... (E) Mar. 1892
Ropner, Robert, Jun., Stockton-on-Tees ... ... (S) Feb. 1886
Rosenthal, James H., Woodville, 97, Eltham Road, Lee, Kent ... (E) Dec. 1896
Roseti, Capt. G. Sundblad, Callao 1442, Buenos Ayres, Argentine Republic ... ... (N A) June 1896
Ross, Charles, c/o Messrs. Smith's Dock Co., Ltd., High Docks, South Shields ... ... (E) Jan. 1898
Ross, William, 20, Meadow Side, Dundee ... ... (E) May 1893
Rosser, W. D., c/o Messrs The Penarth Shipbuilding and Ship-repairing Co., Penarth Dock, Cardiff ... ... (S) Nov. 1893
Rowan, Jas., 231, Elliott Street, Glasgow ... ... (E) Nov. 1886
Rowell, G. W., 22, Armstrong Road, New Benwell, Newcastle-upon-Tyne ... ... (E) Feb. 1885
Rowell, H. B., Cleugh Brae, Jesmond East Park, Newcastle-upon-Tyne (*Life Member*) ... ... (S) Nov. 1884
Rusden, L., 14, Sanderson Road, Jesmond, Newcastle-upon-Tyne (E) Nov. 1884
Russell, F. Herbert, Scotia Engine Works, Sunderland ... ... (E) Oct. 1891
Rutherford, G., Messrs. Mercantile Pontoon Co., Roath Dock, Cardiff (S) Oct. 1886
Rutherford, J. T., 39, Osborne Road, Stroud Green Road, London, N. ... ... (E) Graduate, Jan. 1886; Member, Nov. 1893
Rutherford, Robert T., 34, Denmark Street, Gateshead-on-Tyne ... (E) Nov. 1899
Ryder, C. L., Messrs. The London Salvage Association, Mount Stuart Square, Cardiff ... ... (E) Oct. 1886

ELECTED.

S.

Salmon, P., 5, The Oaks West, Sunderland ... ... (E SUR) Nov. 1884
Sambidge, James, c/o Messrs. J. H. Holmes & Co., Portland Road, Newcastle-upon-Tyne ... ... (E E) Nov. 1891
Sandeman, John Watt, 2, St. Nicholas' Buildings, Newcastle-upon-Tyne... ... ... (E) Oct. 1891
Sanderson, J., 31, Park Road, Jarrow-on-Tyne ... ... (S) Nov. 1884
Sandison, M., 3, Devonshire Terrace, Newcastle-upon-Tyne ... (E) Dec. 1884
Sawyer, John, c/o Messrs. Thos. Wilson, Sons, & Co., Hull ... (E) Oct. 1886
Schaeffer, A. G., 16, Lombard Street, Newcastle-upon-Tyne ... (E) Nov. 1884
Scott, Ernest, Close Engine Works, Newcastle-upon-Tyne ... (E E) Nov. 1884
Scott, George, 36, Bede Burn Road, Jarrow-on-Tyne ... (S) { Graduate, Jan. 1900 / Member, May 1901
Scott, James, c/o Messrs. Consett Iron Co., Blackhill, Co. Durham (E) Oct. 1892
Scott, Joseph, 49, Leazes Terrace, Newcastle-upon-Tyne (E) { Graduate, Dec. 1891 / Member, Oct. 1898
Scott, Joseph R., 9, Queen Street, Newcastle-upon-Tyne ... ... (E) Oct. 1887
Scott, Walter, 30, Bellevue Crescent, Ayr ... ... (NA) Mar. 1897
Scott, William, c/o Messrs. R. & W. Hawthorn, Leslie & Co., St. Peter's, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Scott, William, Lyndhurst, 19, Plasturton Avenue, Cardiff ... (E) June 1896
Seabury, Edward, Burnt Mill House, Harlow, Essex ... ... (E) Mar. 1886
Seaman, C. J., 134, High Street, North Stockton-on-Tees ... ... (E) Jan. 1889
Seaton, Albert Edward, Messrs. Earle's Shipbuilding Co., Hull ... (E) Jan. 1891
See, Horace, 1, Broadway, New York City, U.S.A. ... ... (E) May 1896
Sergent, William John, 4, Hereford Road, Seaforth, near Liverpool ... ... (E) Oct. 1898
Shand, H., 64, Queens Road, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Sharp, A. E., c/o Messrs. The Peninsular and Oriental Steam Navigation Co., 122, Leadenhall Street, London, E.C. ... (E) Nov. 1884
Sharp, Mark, 144, Albert Road, Jarrow-on-Tyne ... ... (E) Dec. 1889
Shaw, Jas., 26, Sandhill, Newcastle-upon-Tyne ... ... (M SUR) Jan. 1885
Shaw, Thomas, Messrs. Lloyd's Register of Shipping, 3, St. Nicholas Buildings, Newcastle-upon-Tyne ... ... (SUR) Nov. 1900
Sheriff, Thomas, c/o Messrs. Robert Mackill & Co., 53, Bothwell Street, Glasgow ... ... (E) April 1890
Short, John Gill, 57, John Street, Sunderland ... ... (NA) Feb. 1899
Short, Jos., 13, John Street, Sunderland ... ... (S) Nov. 1884
Short, Thomas S., c/o Messrs. Short Brothers, Pallion, Sunderland ... ... (S) { Graduate, Oct. 1892 / Member, May 1899
Shute, A. E., 12, Clyde View, Partick, Glasgow ... ... (E) Dec. 1892
Sibun, William, Lloyd's Register of Shipping, Bute Docks, Cardiff ... ... (SUR) Mar. 1896
Simpson, Kenneth, c/o Messrs. John Brown & Co., Clydebank Shipbuilding Yard, Glasgow ... ... (S) { Graduate, Dec. 1893 / Member, Oct. 1895
Sinclair, R., c/o Messrs. J. Wildridge & Sinclair, Consulting Engineers, 97, Pitt Street, Sydney, N.S.W., Australia .. (C E) Nov. 1884
Sinton, John K., 26, Sandhill, Newcastle-upon-Tyne ... .. (E) Nov. 1885
Sisson, Wm., Gloucester ... ... (E & N A) Oct. 1888
Sivewright, G. W., 5, Radcliffe Terrace, Hartlepool ... ... (S) Nov. 1886
Skentelbery, Charles, c/o Messrs. Jacobs, Davies, and Barringer, 153, Mick Street, Boston, U.S.A. ... ... (E) Oct. 1900

ELECTED.

Skentelbery, Joseph W., 7, Washington Terrace, North Shields ... (E) Dec. 1900

Skinner, Leslie, 22, Ravensbourne Terrace, South Shields (S) { Graduate, Dec. 1886 / Member, Oct. 1891

Smith, C. E., Cowesby, Clifton Avenue, West Hartlepool ... (E) Nov. 1888

Smith, Eustace, Guildhall, Newcastle-upon-Tyne ... ... (S) Nov. 1884

Smith, E. J., Haughton-le-Skerne, Darlington ... ... (E) Dec. 1900

Smith, L. Eustace, Roseworth Cottage, Moor Road, Gosforth, Newcastle-upon-Tyne ... ... (E) { Graduate, Oct. 1889 / Member, Oct. 1892

Smith, Thomas, Steam Crane Works, Old Foundry, Rodley, near Leeds (E) Oct. 1888

Smith, Thomas Edward, Messrs. John Smith & Sons, Newgate Street, Newcastle-upon-Tyne ... ... (E) April 1885

Smith, Wm., 152, Roker Avenue, Sunderland, M. ... ... (E) Nov. 1884

Smith, Wm. Stawart, West Villa, The Green, Wallsend-on-Tyne ... ... (S) { Graduate, Nov. 1893 / Member, Dec. 1897

Sneddon, Alex. Russell, Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London, E.C. ... ... (E SUR) Nov. 1899

Snook, Francis W. G., 32, Sunbury Avenue, West Jesmond, Newcastle-upon-Tyne ... ... (E) Dec. 1896

Soliani, Nabor, Col., Direttore del Cantiere Ansaldo, Sestri-Ponente, Italy ... ... (S) Jan. 1885

Spark, H. King, Messrs. The Anti-Attrition Metal Co., Ltd., Emerson Street, Southwark, London, S.E. ... ... (E) May 1898

Spear, John, c/o Messrs. T. Wilson & Sons, Hull ... ... (E) Oct. 1887

Spearman, Richard, Eachwick House, Dalton, Newcastle-upon-Tyne (E) Feb. 1889

Spence, W. G., c/o Messrs. Wigham Richardson & Co., Neptune Works, Walker-on-Tyne (*Life Member*) ... ... (E) Nov. 1884

Spencer, Donald, 332, Stanhope Road, Tyne Dock, South Shields... (S) Oct. 1898

Spencer, J. W., Newburn Steel Works, Newburn-on-Tyne ... (E) Feb. 1885

Squire, Charles E., 4, Eden Place, Newcastle Road, Sunderland ... ... (E E) { Graduate, Nov. 1893 / Member, Oct. 1898

Staig, William Andrew, Station Road, Wallsend-on-Tyne ... (E) Feb. 1897

Stanley, John T., 70, Falmouth Road, Heaton, Newcastle-upon-Tyne ... ... (E) Oct. 1898

Stansfield, George R., 1, Linden Gardens, Harton Village, South Shields... ... ... (E) Mar. 1891

Stephen, A. E., Linthouse, Govan, Glasgow ... ... (E & S) June 1896

Stephen, John Murray, Linthouse Engine Works, Govan, Glasgow (E) Oct. 1895

Stephens, H. C. J., 94, Fortress Road, Kentish Town, London, N.W. ... ... (E) { Graduate, Oct. 1890 / Member, Nov. 1897

Stephens, Thomas S., 16, Archbold Terrace, Jesmond. Newcastle-upon-Tyne ... ... (E) April 1901

Stephenson, Bernard, 30, The Esplanade, Greenock ... ... (E) Dec. 1896

Stephenson, C., 2, Elm Terrace, The Green, Wallsend-on-Tyne ... (S) Nov. 1884

Stevenson, Robert, Bentham Buildings, The Side, Newcastle-upon-Tyne ... ... (E) Oct. 1900

Stevenson, Wm., Bank Chambers, Sandhill, Newcastle-upon-Tyne (E) Nov. 1884

Stewart, James, 13, Otterburn Terrace, Jesmond, Newcastle-upon-Tyne... ... ... (E) Oct. 1890

Stirling, Andrew, Jun., 1, Greenvale Terrace, Dumbarton... ... (E) Feb. 1888

Stirzaker, J. C., 16, Grosvenor Place, Newcastle-upon-Tyne ... (E) Nov. 1884

Stoddart, A. Lane, York House, Heworth Village, Felling-on-Tyne, R.S.O. ... ... (S) Nov. 1898

ELECTED.

Stoddart, J. E., Lloyd's Register of Shipping, White Lion Court, Cornhill, London, E.C. ... ... (E SUR) Oct. 1888

Stoddart, Swinton, 5, Ormonde Street, Sunderland ... (S) { Graduate, May 1885 / Member, Nov. 1892

Stupersky, Antony, 37, George Street, Willington Quay-on-Tyne ... (S) May 1901

Summers, James, 4, Vicarage Terrace, Newtown, Stockton-on-Tees ... ... (E) Mar. 1889

Surtees, Charles, 4, Cardwell Street, Roker, Sunderland ... ... (S) Dec. 1900

Surtees, Francis V., Banham, Renfrew ... ... (S) Dec. 1892

Surtees, R., 22, Alexander Terrace, Gateshead-on-Tyne ... (E) Nov. 1884

Swan, A. S., Printing Court Buildings, Newcastle-upon-Tyne ... (S) Nov. 1888

Swan, Charles Sheriton, c/o Messrs. C. S. Swan & Hunter, Wallsend-on-Tyne... ... ... (S) { Graduate, Nov. 1890 / Member, Mar. 1894

Swan, H. F., North Jesmond, Newcastle-upon-Tyne (*Life Member*) (S) Nov. 1884

Swainston, William, 103, Cardigan Terrace, Heaton, Newcastle-upon-Tyne ... ... (FM) Nov. 1900

Swinburne, M. W., 117, Park Road, Newcastle-upon-Tyne ... (E) Nov. 1884

Swinburne, Matthew, Frazer Terrace, Heworth, Felling-on-Tyne ... ...(S) { Graduate, May 1899 / Member, April 1901

Swinburne, T. M., 18, Bewick Road, Gateshead-on-Tyne ... ... (E) Jan. 1885

Swinney, W., 10, Wentworth Terrace, Westoe Lane, South Shields (E) Dec. 1888

Syme, James, Fairfield Works, Govan, Glasgow ... ... (E) Oct. 1892

T.

Tate, Chas. H., 7, Side, Newcastle-upon-Tyne ... ... (N A) Nov. 1884

Taylor, Alexander, Maritime Buildings, King Street, Newcastle-upon-Tyne . . .. (E) Nov. 1884

Taylor, John, 1, St. Alban's Place, Tynemouth ... ... (E) Dec. 1894

Teasdale, John, c/o Messrs. Vickers, Son & Maxim, Naval Construction Works, Barrow-in-Furness ... ... (E) Mar. 1898

Terry, F. Herbert, Messrs. Tyne Brass and Copper Tube Manufacturing Co., Jarrow-on-Tyne ... ... (M) Feb. 1901

Thearle, Samuel James P., West View, St. Augustine's Avenue, South Croydon, Surrey ... ...(SUR) Feb. 1899

Thomas, Benjamin, 25, Seventh Avenue, Heaton, Newcastle-upon-Tyne ... ... (E) Feb. 1899

Thomas, William, 4, Eton Avenue, Hampstead, London, N.W. ... ... (E) { Graduate, Oct. 1895 / Member, Nov. 1899

Thompson, Arthur E., 19, The Crescent, Gateshead-on-Tyne ... (E) May 1898

Thompson, C. E., Thornbeck, Thornhill Park, Sunderland ... (S) Nov. 1884

Thomson, Ernest Routledge, 40, Cavendish Place, Newcastle-upon-Tyne ... ... (S) Nov. 1900

Thompson, Jas., 2, Carlton Terrace, Sunderland ... ... (E) Dec. 1886

Thompson, John Augustus, 9, Billiter Square, London, E.C. (E & N A) Oct. 1892

Thompson, J. L., Westholme Hall, Winston-on-Tees ... ... (S) Nov. 1884

Thompson, Robert, North Sands Shipyard, Sunderland ... ... (S) Nov. 1884

Thomson, James, M.A., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Ordnance Works, Elswick, Newcastle-upon-Tyne ... ... (E & N A) Nov. 1890

Thorn, W. H., 5, Waterville Terrace, North Shields ... ... (E) Nov. 1884

Thornton, James M., c/o Messrs. R. Gordon & Co., Post Office Buildings, Hudson Street, South Shields ... ... (E) April 1893

ELECTED.

Thorman, Thos., 40, Kings Road, Leytonstone, Essex ... ... (E) Mar. 1901
Thornton, Thomas Lee, c/o Messrs Lloyds Register of Shipping, Dock Office Building, West Hartlepool ... ... (E) Feb. 1898
Thyne, John Sinclair, 17, Boughton Street, Sunderland ... ... (S) Dec. 1899
Tinn, Fred. D., North View, Mowbray Road, South Shields ... (S) Nov. 1891
Tinn, George, 205, Cardigan Terrace, Gateshead-on-Tyne ... ... (E) Dec. 1897
Tobin, Thos. Charles, 16, Beech Grove Road, Newcastle ... ... (S) Feb. 1901
Tocher, J. W., c/o Messrs. Wallsend Slipway and Engineering Co., Wallsend-on-Tyne ... ... (S) Mar. 1898
Todd, John P., 13, Chatsworth Street, Sunderland ... ... (E) Dec. 1897
Todd, George William, 126 Bede Burn Road, Jarrow-on-Tyne (S) { Graduate, Jan. 1898 / Member, Dec. 1899
Toomer, C. R., Ravensworth, Westoe, South Shields ... ... (E) Jan. 1899
Toovey, Alfred F., Ovington Cottage, Prudhoe, Northumberland (E) Dec. 1894
Torrance, Robert Patterson, Heworth Old Vicarage, Felling-on-Tyne ... ... (E) April 1901
Tose, Thomas, 30, Thornton Street, West Hartlepool ... ... (E) Mar. 1901
Towers, Edward, Jun., 4, Latimer Street, Tynemouth (E) { Graduate, Nov. 1886 / Member, Oct. 1888
Toyne, G. A. Dryden, Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (SUR) April 1899
Trail, John, 21, Grosvenor Place, Jesmond, Newcastle-upon-Tyne ... ... (M S) Oct. 1892
Traill, Robert, 8, Newcastle Street, North Shields ... ... (E) Oct. 1896
Trechmann, J. E., Norton Lodge, Stockton-on-Tees ... ... (E) Feb. 1898
Trewent, F. J., 43, Billiter Buildings, Billiter Street, London, E.C. ... ... (S) Dec. 1884
Trowell, Wm. John, Board of Trade Surveyor's Offices, Custom House, Arcade, Liverpool ... ... (E) Oct. 1894
Turnbull, John, 18, Meldon Terrace, Heaton, Newcastle-upon-Tyne (E) Nov. 1898
Turner, S. J., 71, Warwick Street, Heaton, Newcastle-upon-Tyne (E) Mar. 1887
Turpie, David Whyte, c/o Messrs. W. Pickersgill & Sons, Southwick, Sunderland ... ... (S) Dec. 1895
Tuxen, Holger, Bureau Veritas Register of Shipping, Heibersgade, 14, Copenhagen, K. ... ... (S) Nov. 1896
Twaddell, James L., Green Bank, Jarrow-on-Tyne ... ... (S) Oct. 1891
Tweedy, G. F., Kelso House, Newcastle-upon-Tyne .... (E) May 1899
Tweedy, J., Neptune Works, Walker-on-Tyne ... ... (E) Nov. 1884
Tweedy, John, 5, Bellevue Terrace, North Shields ... ... (E) April 1899

U.

Ulm, John, The Arsenal, Pola, Austria ... ... (E) Nov. 1885
Urquhart, Douglas M., 13, Gill Side Grove, Roker, Sunderland ... (S) May 1899

V.

Vardy, George, 188, Helmsley Road, Newcastle-upon-Tyne (E) { Graduate, Oct. 1894 / Member, 1898
Varty, Bartholomew Snowball, Classensgade 26, Stuen Poterbro, Copenhagen ... ... (S) { Graduate Oct. 1895 / Member May 1901

ELECTED.

Vianson, N. E., *viâ* Corsica 20/5, Genoa, Italy ... ... (E) Dec. 1885
Vick, R. W., Messrs. Furness, Withy & Co., Middleton Shipyard, West Hartlepool ... ... (S) Nov. 1888
Vowell, Josias, Boys' Industrial School, Thomas Street, Sunderland (E) Feb. 1901

W

Wadagaki, Yasuzo, Navy Department, Tokio, Japan ... ... (E) Jan. 1891
Wait, Thomas Herbert, Cail's Buildings, Quayside, Newcastle-upon-Tyne ... ... (C E) Dec. 1893
Wake, Tom, 2, Cliff Terrace, Hartlepool ... ... (E) April 1892
Wakeham, John F., 21, Tenth Avenue, Heaton, Newcastle-upon-Tyne ... ... (S) { Graduate, Mar. 1893 / Member, Oct. 1895
Walker, Archibald, 143, Leith Walk, Leith, N.B. ... ... (E) April 1887
Walker, Henry, 11, Oxford Terrace, Gateshead-on-Tyne ... ... (E E) Feb. 1893
Walker, James, c/o Messrs. River Tyne Commissioners' Office, Bewick Street, Newcastle-upon-Tyne ... ... (C E) Nov. 1898
Walker, John, c/o Messrs. R. Stephenson & Co., Limited, South Street, Newcastle-upon-Tyne ... ... (E & S) Nov. 1891
Walker, Sept. H., 37, Washington Terrace, North Shields ... (E) Nov. 1899
Wallau, J., 16, Woodhouse Terrace, Gateshead-on-Tyne ... ... (E) Nov. 1884
Waller, Thomas Naunton, 10, Holly Avenue, Jesmond, Newcastle-upon-Tyne ... ... (E) May 1898
Walliker, John George, c/o Messrs. Hodges & Walliker, Barry Docks, South Wales ... ... (E) May 1896
Wallis, Robert, Wh.Sc., Point Pleasant House, Wallsend-on-Tyne (E) April 1891
Walter, Max, Norddeutscher Lloyd, Central Bureau, Bremen ... (S) Feb. 1893
Walton, J. G., 26, Fenchurch Street, London, E.C. ... ... (E) Nov. 1884
Walton, Samuel, 5, Tyne View Terrace, South Shields ... ... (E) Dec. 1893
Warburton, F. J., 3, St. Nicholas' Buildings, Newcastle-upon-Tyne (C E) May 1900
Warburton, J., 4, Beauclerc Terrace, Sunderland ... ... (S) Nov. 1884
Warburton, John Arthur, 13, Grindon Terrace, Sunderland (E) { Graduate, Mar. 1894 / Member, Nov. 1896
Ward, Herbert John, Mill Hey, Eastham, Birkenhead, Cheshire (SUR) Nov. 1898
Ward, John, c/o Messrs. W. Denny & Bros., Dumbarton ... ... (S) Dec. 1891
Wardale, Henry, 9, Woodhouse Terrace, Gateshead-on-Tyne ... (E) Feb. 1888
Warden, Thomas M., 21, Windermere Street, Gateshead-on-Tyne (E) Oct. 1894
Watson, Michael, 4, St. Nicholas Buildings, Newcastle-upon-Tyne (C E) Oct. 1900
Watson, Thomas Henry, 10, Neville Street, Newcastle-upon-Tyne (SUR) Jan. 1896
Watts, James Arthur, 16, Westoe Parade, South Shields ... ... (E) Nov. 1900
Watts, Philip, Elswick Shipyard, Newcastle-upon-Tyne ... ... (S) Nov. 1885
Wawn, Tom Noel, c/o Messrs. Lloyd's Register of Shipping, Franklinstrasse 30, Dusseldorf, Germany ... ...(SUR) Jan. 1900
Webster, William Milne, 23, North View Heaton, Newcastle-upon-Tyne ... ... (E) Nov. 1900
Weidemann, Nils, Det-Norske Veritas, Christiania, Norway ...(SUR) Jan. 1892
Weighton, R. L., M.A., 2, Park Villas, Gosforth, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Weir, George Dobie, Sunderland Engine Works, South Docks, Sunderland ... ... (E) Oct. 1894
Weir, John, c/o Messrs. J. Scott & Co., Abden Works, Kinghorn, N.B. ... ... (E) Nov. 1884

ELECTED.

Weir, William, 190, Nithsdale Road, Pollokshields, Glasgow ... (E) Nov. 1889
Welton, J. G., 41, Sydenham Terrace, Sunderland .. .. (E) Nov. 1893
West, Henry H., British and Foreign Chambers, 5, Castle Street, Liverpool ... ... (E & N A) Oct. 1886
Westgarth, Tom, Messrs. Richardsons, Westgarth & Co., Middlesbrough ... ... (E) Oct. 1886
Westmacott, Alfred, Foreland House, Bembridge, Isle of Wight ... ... (E) { Graduate, Dec. 1885 / Member, Nov. 1892
Westmacott, P. G. B., Rose Mount, Sunninghill, Berks ... ... (E) Nov. 1884
Wheater, Chas. Busfield, 73, Rothbury Terrace, Heaton, Newcastle-upon-Tyne ... ... (E) Oct. 1894
White, A. F., 2, Fenchurch Avenue, London, E.C. ... ... (E) Feb. 1901
White, C., 13, Mosley Street, Newcastle-upon-Tyne ... ... (E) Nov. 1884
White, R. Saxon, Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Walker-on-Tyne ... ... (S) Nov. 1884
Whitfield, Ernest, 11, Victoria Terrace, Low Fell, Gateshead-on-Tyne... ... ... (E) Dec. 1899
Whitfield, Thomas, Messrs. Tyne Dock Engineering Co., South Shields ... ... (E) April 1896
Whittaker, Frederick W., Dockyard, Coburg Dock, Messrs. Mersey Docks and Harbour Board, Liverpool ... ... (E) Oct. 1892
Whyte, Wm., Eastrigg, Corbridge-on-Tyne ... ... (E) Nov. 1884
Widdas, T. D., 56, Plasturton Avenue, Cardiff ... ... (SUR) April 1885
Wight, Henry D., 7, Holmlands Park, Sunderland ... ... (E E) Dec. 1898
Wildridge, Richard, c/o R. W. Brachead, Bury Street, N. Sydney, N.S.W. ... ... (E) { Graduate, Oct. 1895 / Member, Oct. 1898
Wilkin, Ernest V., 47, Saint Mary Axe, London, E.C. (C E) { Graduate, Nov. 1892 / Member, Oct. 1898
Wilkinson, Thomas, 9, Laburnum Avenue, Wallsend-on-Tyne ... (S) Nov. 1899
Willcox, Henry Walker, 15, Norfolk Street, Sunderland ... ... (C E) Nov. 1897
Willcox, Percy F. C., 15, Norfolk Street, Sunderland ... ... (C E) Nov. 1897
Willcox, R. J. N., 3, The Oaks West, Sunderland ... (E) { Graduate, Mar. 1892 / Member, Dec. 1897
Williams, M. Lucas, 14, Barratt Street, Stockton-on-Tees... ... (E) Nov. 1900
Williams, Thomas, Messrs. South Durham Steel & Iron Co., West Hartlepool ... ... (I & S M) Dec. 1900
Williams, Thomas R., 142, Bede Burn Road, Jarrow-on-Tyne ... (S) Oct. 1895
Williamson, Robt. Tate, 119, Bede Burn Road, Jarrow-on-Tyne ... (E) Oct. 1900
Wilson, Henry J. H., 117, Bede Burn Road, Jarrow-on-Tyne ... ... (E) Nov. 1895
Wilson, James, Messrs. Richardsons, Westgarth & Co., Hartlepool Engine Works, Hartlepool ... ... (E) Jan. 1896
Wilson, John Paul, Messrs Palmer Shipbuilding Co., Jarrow-on-Tyne ... ... (S) Oct. 1895
Wilson, John Reginald, Lyndhurst, Gosforth, Newcastle-upon-Tyne ... ... (E E) { Graduate, Mar. 1894 / Member, Dec. 1899
Wilson, William S., 123, Osborne Road, Jesmond, Newcastle-upon-Tyne ... ... (E E) { Graduate, Nov. 1891 / Member, Mar. 1901
Wimble, Arthur, 1, Queen Street, Jersey ... ... (E) Dec. 1893
Winstanley, P. D., Bureau Veritas Register of Shipping, 155, Fenchurch Street, London ... ... (S) Nov. 1884

ELECTED.

Winter, Thor., Boulevards-gaten, 21, Helsingfors, Finland ... (E) Nov. 1893
Withy, H., Middleton Shipyard, West Hartlepool ... ... (S) Nov. 1884
Wood, Henry Alfred, Oakfield Road, North Ormesby, Middlesbrough-on-Tees ... ... (S) Dec. 1893
Wood, John Scott, 6, Eslington Terrace, Newcastle-upon-Tyne ... ... (S) { Graduate, Oct. 1891 / Member, Oct. 1896
Wood, Joseph, Foundry Manager, Deptford Yard Brass Works, Sunderland... ... ... (E) Mar. 1895
Wood, William, 6, Eslington Terrace, Newcastle-upon-Tyne ... (S) Nov. 1897
Wortley, Henry B., Kent House, Egerton Park, Rock Ferry, Birkenhead... ... ... (S) { Graduate, Jan. 1886 / Member, Nov. 1892
Wotherspoon, James Douglas, 39, Hainton Street, Grimsby ... (E) April 1900
Wray, Thomas W., Board of Trade Offices, Sunderland ... ...(SUR) Jan. 1895
Wright, R., 5, Hawthorn Terrace, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Wright, William Charles, 17, Wansbeck Gardens, West Hartlepool (E) Feb. 1898
Wyse, Thomas, North Lodge, Walker-on-Tyne ... ... (E) Nov. 1898

Y.

Young, Andrew, Bureau Veritas. Register of Shipping, 155, Fenchurch Street, London, E.C. ... ... (S) { Graduate, Feb. 1892 / Member, May 1893
Young, J. Denholm, 2A, Tower Chambers, Liverpool ... ... (E) Oct. 1888
Younger, R. Elmire House, Heaton, Newcastle-upon-Tyne ... (E) Nov. 1884

Z.

Zeeman, J. H., c/o Nederlandsch Indische Houtaankap, Maatschappij, Semerang, Java ... ... (S) Oct. 1889

ASSOCIATES.

A.

Andersen, Andrew P., Haldane House, Jesmond, Newcastle-upon-Tyne... ... ...(S O) Nov. 1899
Anderson, Daniel G., c/o Messrs. W. Angus & Co., Grainger Street West, Newcastle-upon-Tyne ... ... (A) Nov. 1893
Armstrong, S., Clifton Avenue, West Hartlepool ... ... (A) Nov. 1888
Armstrong, Thomas Henry, Blanchland House, Willington-Quay-on-Tyne ... ...(E A) Nov. 1900
Arnott, James, 25, Dean Street, Newcastle-upon-Tyne ...(S O) Oct. 1895

B.

Barklam, George, Burnt Tree Villa, Tipton, Staffordshire ... (A) April 1888
Barr, John Smith, 16, Broad Chare, Quayside, Newcastle-upon-Tyne... ... ... (A) Nov. 1893
Barwick, J. S., Ashbrook Grange, Sunderland ... ...(S O) Nov. 1884
Beynon, Thomas, 9, Dean Street, Newcastle-upon-Tyne ... ...(E A) Oct. 1891
Bigge, C. W., Northern Counties Club, Newcastle-upon-Tyne ... (A) Dec. 1889
Bingham, Col. J. E., West Lea, Ranmoor, Sheffield... ... ... (M) Mar. 1895
Bird, William, 22, Percy Gardens, Tynemouth ... ... (A) May 1896
Borrie, Walter, Messrs. Blair & Co., Ltd., Stockton-on-Tees ... (A) Jan. 1899
Briggs, R. S., Moorlands, Sunderland ... ...(S O) Dec. 1886
Brims, D. N., 4, St. Nicholas' Buildings, Newcastle-upon-Tyne ... (C) Nov. 1893

ELECTED.

Brown, Charles Ernest, 1, Ashleigh Villas, East Boldon, near Sunderland ... ... (A) Oct. 1900
Brown, Percy Ledger, 1, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (E A) Oct. 1896
Brunton, John, 3, Prior's Terrace, Tynemouth ... ... (S O) Oct. 1886
Bullen, Tempest C., c/o Messrs. H. E. Moss & Co., 8, Exchange Buildings, Newcastle-upon-Tyne ... ... (S O) Nov. 1891

C.

Caminos, J. L. ... ... June 1896
Carr, Ralph, Thornleigh, Clayton Road, Newcastle-upon-Tyne (A & S O) Nov. 1886
Caws, Frank, 22, Fawcett Street, Sunderland ... ... (C E) Oct. 1892
Cay, Arthur, Messrs. Cay, Hall & Co., Exchange, Cardiff ... ... (S O) Nov. 1884
Cohan, Edward Asher, 2, Rumford Place, Liverpool ... ... (S O) Nov. 1889
Cory, John, Cardiff ... ... (S O) June 1896
Coull, John, Baltic Chambers, Quayside, Newcastle-upon-Tyne ... (S O) Oct. 1886
Coverdale, R. H., Messrs. J. Coverdale & Sons, Steamship Owners, West Hartlepool ... ... (S O) Nov. 1888
Craik, A., 49, Alma Place, North Shields ... ... (A) June 1896
Crawford, Thomas, 10, Haldane Terrace, West Jesmond, Newcastle-upon-Tyne ... ... (A) Oct. 1896
Crosier, Edward James, 3, The Hawthorns, East Boldon ... ... (A) Oct. 1889
Culley, F. I., Northumberland Terrace, Tynemouth ... ... (A) Nov. 1899
Culliford, J. H. W., 45, West Sunniside, Sunderland ... ... (S O) Nov. 1884

D.

Dodds, E. F., 36, Side, Newcastle-upon-Tyne ... ... (A) Nov. 1893
Dodds, John B., 36, Side, Newcastle-upon-Tyne ... ... (CHEM) Oct. 1888
Donkin, Geo., Jun., 50, Grove Street, Newcastle-upon-Tyne ... (A) April 1897
Dove, Edward John, 5, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (M) Oct. 1890
Douglass, John, c/o Messrs. Walker & Hall, 60, Grey Street, Newcastle-upon-Tyne ... ... (A) Oct. 1898

E.

Eccles, Edward, Royal Insurance Buildings, Queen Street, Newcastle-upon-Tyne (*Life Associate*) ... ... (S O) Oct. 1887

F.

France, James A., St. John Street, Newcastle-upon-Tyne ... (M) Jan. 1898
Frazer, Joseph S., Britannia Buildings, Cardiff .. .. (M) June 1896
Furness, Sir Christopher, Baltic Chambers, West Hartlepool .. (S O) Oct. 1888
Forster, George, 8, Warwick Street, Heaton, Newcastle-upon-Tyne Oct. 1898

G.

Graham, Frank, Bank Chambers, Mosley Street, Newcastle-upon-Tyne ... ... (E A) Nov. 1891
Geary, William, Parkside, St. Aidan's Road, South Shields ... (M S) May 1899

H.

Hardy, John, Jun., Brunswick Street, West Hartlepool ... ... (I M) Nov. 1893
Harland, George, 1, Westoe Crescent, South Shields ... ... (A) Dec. 1888

ELECTED.

Harrison, Samuel Turner, The Green, Wallsend ... ... (A) Nov. 1897
Harrison, Thomas, 9, Bridge Street, Sunderland ... ... (A) Dec. 1894
Hedley, John H., 7, Ashbrook Terrace, Sunderland... ... ... (S) Dec. 1886
Hedley, Robert, The Poplars, Spennymoor ... ... (A) Nov. 1899
Henderson, John T., 5, Logan Terrace, South Shields ... ... (M) May 1900
Henzell, Robert, Northern Oil Works, Newcastle-upon-Tyne (*Life Associate*) ... ... (A) Nov. 1893
Heslop, Richard O., Akenside Hill, Newcastle-upon-Tyne... (I & S M) Oct. 1885
Hinchliffe, John, 25, Hawthorn Street, Newcastle-upon-Tyne ... (A) Nov. 1899
Hodges, Thomas Wm., 86, Osborne Road, Newcastle-upon-Tyne ... ... (A) Nov. 1899
Hogg, John Thomas, Tyneside Brass Works, Barry Docks, South Wales ... ... (I & S M) April 1896
Holliday, Henry, Beechgrove, Blackhill, Co. Durham ... ... (A) Nov. 1895
Hollis, John, 29, Alexandra Place, Newcastle-upon-Tyne... ...(S M) May 1901
Holzapfel, Max, Maritime Buildings, Quayside, Newcastle-upon-Tyne ... ... (M) May 1900
Hudson, Ralph M., Jun., 8, The Cedars, Sunderland ... ... (S O) Dec. 1886
Hudson, Robert, 24, Hotspur Street, Tynemouth ... ... (A) Nov. 1895
Hunting, Charles S., 1, Exchange Buildings, Quayside, Newcastle-upon-Tyne ... ...(S O) April 1886

I.

Innes, Charles H., Rutherford College, Newcastle-upon-Tyne ... (E) Oct. 1891

J.

Jobson, W. J., c/o Messrs. Robert Stephenson & Co., South Street, Newcastle-upon-Tyne ... ... (A) May 1889
Jordan, John George, 6, Cedars Crescent, Ryhope Road, Sunderland ... ... (A) Nov. 1892

K.

Knott, James, Prudential Buildings, Newcastle-on-Tyne ... ...(S O) Dec. 1896

L.

Lloyd, John, Deptford Shipyard, Sunderland ... ... (A) Oct. 1894
Lockie, John, 21, Dean Street, Newcastle-upon-Tyne ... ...(S O) Oct. 1892
Lodwidge, Philip, Baltic Chambers, Sunderland ... ... (A) June 1896
Lord, W. R., 41, Queen's Road, Jesmond, Newcastle-upon-Tyne ...(M M) Feb. 1900
Lucock, George, Dean House, Tyne Dock ... ... (M) Oct. 1900

M.

Macarthy, George E., 9, Dean Street, Newcastle-upon-Tyne ...(S O) Oct. 1887
Mail, Douglas B., 3, St. George's Terrace, Jesmond, Newcastle-upon-Tyne ... ...(M S) Feb. 1895
Maughan, William, 13, Mosley Street, Newcastle-upon-Tyne ... (A) Feb. 1887
McBeath, Harry C., Stromness, Billingham, Stockton-on-Tees ... (A) Dec. 1900
McIntosh, R. Y., 34, Dean Street, Newcastle-upon-Tyne ... ... (E A) Nov. 1891
MacIntyre, John, 3, Abbotsford Terrace, Newcastle-upon-Tyne... (S O) Jan. 1885
Meek, John George, 13, Belle Vue Park, Sunderland ... ... (A) Dec. 1894
Milburn, J. D., Queen Street, Newcastle-upon-Tyne ... ...(S O) Nov. 1884

ELECTED.

Miller, T. R., 9, Great St. Helen's, London, E.C. ... ... (A & S O) Nov. 1884
Mitcalfe, John Stanley, Chairman of Northern Maritime Insurance Co., Maritime Buildings, Newcastle-upon-Tyne ... (A & S O) Jan. 1892
Moody, George Clark, H, King Street, Newcastle-upon-Tyne ... (S O) April 1900
Morton, Benjamin, 18, St. George's Square, Sunderland ... ...(SUP) Dec. 1895
Mulherion, G. F., Birtley Avenue, Tynemouth ... ... (A) Nov. 1884
Muller, J. C. F., 22, Vieille Route, Antwerp ... ...(SUR) Feb. 1890
Murray, Matthew, The Green, Wallsend-on-Tyne ... ... (A) Nov. 1893

N.

Nielsen, Hans Christian, 12, Cliff Terrace, Hartlepool ... ... (S O) Feb. 1898
Nixon, John, c/o Messrs. Blyth Shipbuilding Co., Blyth ... ... (A) Oct. 1894

O.

Olsen, Hans Benedick, 70, Church Street, West Hartlepool ... (S O) Mar. 1893
Osbourne, Jas., 6, Ashbrook Terrace, Sunderland ... ... (S) Jan. 1885

P.

Park, Robert, Lauriston, Blackhill, Co. Durham ... ... (A) Dec. 1897
Parker, George, 62, John Street, Sunderland ... ... (A) Dec. 1899
Patterson, Thos., 2, The Elms, Sunderland ... ... (S) Jan. 1885
Petersen, William, Messrs. Petersen & Tate, Bank Chambers, Sandhill, Newcastle-upon-Tyne... ... ... (S O) Nov. 1893
Phalp, Oliver, Almora, 37, Richmond Road, Cardiff ... ...(SUR) Feb. 1889
Pinkney, Thomas, 3, Ashbrook Terrace, Sunderland ... ... (S O) Dec. 1886
Potts, Turnbull, Tyne Docks, South Shields... ... ... (SUR) Nov. 1898
Pringle, George Frederick, 29, Grainger Street West, Newcastle-upon-Tyne ... ...(E A) May 1901
Proctor, J. H., 22, Hawthorn Terrace, Newcastle-upon-Tyne ... (I M) Nov. 1893
Pybus, William M., Jun., 85, Osborne Road, Newcastle-upon-Tyne April 1899

R.

Radloff, Captain O., c/o Messrs. Russian Steam Navigation Co., Odessa ... ... (M S) Nov. 1891
Raine, John, Baltic Chambers, Sunderland ... ... (S O) Nov. 1897
Ramsay, J. W., 13, Northbrook Road, Lee, Kent ... ... (A) Feb. 1885
Reichwald, A., Lombard Street, Newcastle-upon-Tyne ... ... (A) Nov. 1884
Reid, Sidney, Printer, Akenside Hill, Newcastle-upon-Tyne ... Nov. 1884
Renwick, G., M.P., Messrs. Fisher, Renwick & Co., Maritime Buildings, King Street, Newcastle-upon-Tyne ... ... (S O) Nov. 1884
Rimer, William Thomas, Craigielea, Low Fell, Gateshead-on-Tyne (M) Nov. 1900
Ritson, Arthur, 30, West Sunniside, Sunderland ... ...(S O) Feb. 1899
Robson, John William, G, King Street, Newcastle-upon-Tyne ... (M) April 1896
Robson, Thos., Causeway House, Sunderland ... ...(S O) Nov. 1884
Roger, Thomas, c/o Messrs. Sir C. Furness, Withy & Co., West Hartlepool ... ... (A) May 1901

S.

Scholefield, A., 17, Sandhill, Newcastle-upon-Tyne ... ... (S O) Nov. 1884
Scott, W. H., Messrs. Scott Brothers, 46, Sandhill, Newcastle-upon-Tyne... ... ...(S O) Nov. 1884

ELECTED.

Sisson, W. E., 9, Northumberland Terrace, Tynemouth ... ... (A) Nov. 1899
Snowdon, W. F., 32, Side, Newcastle-upon-Tyne ... ... (E A) Dec. 1886
Squance, J. W., 13, The Avenue, Sunderland ... ... (M S) April 1888
Stallybrass, William S., 14, Side, Newcastle-upon-Tyne ... ... (M) Mar. 1901
Stephenson, George R., c/o Messrs. N. E. Marine Engineering Co., Northumberland Engine Works, Wallsend ... ... (A) Nov. 1899
Storey, Christopher, 28, Holly Avenue, Jesmond, Newcastle-upon-Tyne... ... ... (A) April 1896
Sutherland, Arthur M., 7, Collingwood Terrace, Newcastle-upon-Tyne ... ... (S O) Nov. 1897

T.

Tate, Arthur, 37, Side, Newcastle-upon-Tyne ... ... (S O) Nov. 1893
Temple, George T., 20, Beach Avenue, Whitley Bay, Northumberland ... ... (A) Jan. 1899
Temple, John, Baltic Chambers, Newcastle-upon-Tyne ... (S U R) Mar. 1901
Thompson, Wm. H., 5, Albany Gardens, Whitley Bay, Northumberland .. .. (A) Nov. 1899
Thompson, V. T., Baltic Chambers, Sunderland ... ...(S O) Dec. 1886
Thorpe, Samuel, 4, Alliance Buildings, George Street, Sheffield (I & S M) Feb. 1901
Todd, John Stanley, Percy Park, Tynemouth ... ... (U) Nov. 1895
Towers, Edward, 4, Latimer Street, Tynemouth ... ... (A) Oct. 1888
Towers, Michael G., Clementhorpe, North Shields ... ... (A A) Dec. 1899
Trechmann, Otto K., Church Street, West Hartlepool ... ... (S O) Oct. 1896
Tully, Robert, 9, The Lawe, South Shields ... ... (M S) May, 1900
Turner, Edwin, 32, Powell Road, Clapton, London, N.E. ... ... (A) Oct. 1895

W.

Wainford, Houston E., 7, St. Paul's Gardens, Spennymoor ... (A) Nov. 1899
Wallace, H. S. (*Life Associate*) ... ... (S) May 1899
Ward, Heber, Messrs. Walker & Hall, Sheffield ... ... (A) Feb. 1901
Watson, Thomas W., Gisburn House, Hartlepool ... ... (M S) Nov. 1890
Weatheral, Henry, 27, Alderson Street, West Hartlepool ... ... (A) Feb. 1893
Weller, William, 7, Lovaine Terrace, North Shields ... ... (S O) Dec. 1899
Wilkie, John William, Prince's Buildings, Quayside, Newcastle-upon-Tyne ... ...(S O) Oct. 1900
Willis, Thomas W., 143, Stockton Road, West Hartlepool ... ... (S O) Nov. 1899
Wilson, F. Alfred, 45, West Sunniside, Sunderland ... ... (I M) Nov. 1893
Winstanley, Robt. Hope, 8, Kenilworth Road, Newcastle-upon-Tyne (A) Nov. 1897
Winter, E. G., 56, Avenue Road, Gateshead-on-Tyne ... ... (A) May 1898

Y.

Yeoman, F., Ship and Steamship Broker, West Hartlepool ... (S O) Nov. 1888
Young, J. A., St. Ann's Rope Works, Newcastle-upon-Tyne ... (R M) May 1901
Younger, Robert Laurie, Messrs. Greenock Steamship Co., Limited, Greenock ... ... (A) Feb. 1889

GRADUATES.

A.

Agar, Alfred, c/o Messrs. Davison & Sons, Sirocco Works, Belfast (E) Oct. 1898
Allen, John C., 14, North Terrace, Newcastle-upon-Tyne ... ... (E) Dec. 1899

		ELECTED.
Andrew, John Davis, 33, Osborne Road, Newcastle-upon-Tyne ...	(E)	Jan. 1898
Armstrong, Harold S., 16, Burden Terrace, Newcastle-upon-Tyne	(E)	Dec. 1900

B.

Beilby, Walter H., 1 Kingsley Place. Heaton, Newcastle-upon-Tyne...	(E E)	Dec. 1900
Bennett, George H., 15, Osborne Terrace, Gateshead-upon-Tyne ...	(S)	Dec. 1900
Berriman, A. E., Fairholme, 99, Second Avenue, Heaton, Newcastle-upon-Tyne	(E E)	Feb. 1900
Bertram, S. Norman, 7, Lovaine Row, Tynemouth	(S)	Feb. 1901
Blake, Lionel J. B., 14, Woodhouse Terrace, Gateshead-on-Tyne...		Nov. 1899
Bocler, Harry, 19, Azalea Terrace South, Sunderland	(N A)	Mar. 1898
Borthwick, Robert J., 8, Kensington Terrace, Newcastle-upon-Tyne...	(E)	Dec. 1894
Bowerbank, Albert William, 48, Walker Terrace, Gateshead-on-Tyne...	(S)	Nov. 1900
Bowmer, Matthew N., 8, Tankerville Terrace, Jesmond, Newcastle-upon-Tyne	(E)	Dec. 1900
Browne, Benjamin C., Jun., 58, Brighton Grove, Newcastle-upon-Tyne...	(E)	Oct. 1898
Bullen, Thos. H., 14, Bede Burn Road, Jarrow		Mar. 1900
Bulmer, Albert Edward, Inglewood, Prescot, Lancashire ...	(E)	Nov. 1895
Burr, Percy B., 16, St. George's Terrace, Newcastle-upon-Tyne ...	(E)	Dec. 1900

C.

Carnegie, Alfred Q., 21, Eldon Place, Newcastle-upon-Tyne ...	(E E)	Nov. 1899
Carr, Ralph, Jun., Thornleigh, Clayton Road, Newcastle-upon-Tyne	(E)	Jan. 1894
Chicken, George Percy, 17, Kenilworth Road, Newcastle-upon-Tyne...	(E)	Dec. 1898
Cothay, Frank H., 38, The Avenue, Sunderland	(E)	Feb. 1901
Coulson, Richard H. A., 12, East View, South Shields	(E)	April 1897
Crawford, J. F., "Palmyra," St. George's Road, Waterloo, near Liverpool	(E)	Nov. 1893
Crewe, Veve	(S)	Nov. 1900
Crookston, David D., 36, Fountayne Road, Stoke Newington, London	(E)	Nov. 1899
Crow, William George, 45, Rye Hill, Newcastle-upon-Tyne ...	(E)	Nov. 1900
Cruickshank, Andrew, 52, Tennant Street, Hebburn-on-Tyne ...	(E)	Nov. 1899
Currie, Hugh B., 48, Jesmond Road, Newcastle-upon-Tyne ...	(E)	Nov. 1897

D.

Danielsen, John William, 24, Cardigan Terrace, Heaton, Newcastle-upon-Tyne	(E)	Mar. 1899
Davison, Joseph P., 107, Clumber Street, Newcastle-upon-Tyne ...	(S)	Oct. 1898
Dewar, John, The Green, Wallsend-on-Tyne	(E)	Nov. 1899
Dilworth-Harrison, D. R., 13, Seymour Terrace, Gateshead-on-Tyne	(E E)	Nov. 1899
Dixon, John Thomas, 27, Meldon Terrace, Heaton, Newcastle-upon-Tyne	(E)	Dec. 1899

ELECTED.

Dobson, William Gordon, The Chesters, Jesmond, Newcastle-upon-Tyne... ... ... (S) Feb. 1896
Donaldson, Henry B., 10, Lily Crescent, Jesmond West, Newcastle-upon-Tyne ... ... (S) Nov. 1897
Dowsen, Junr., Charles, 21, Croft Terrace, Jarrow-on-Tyne ... (S) Feb. 1901
Doxford, Robert, Jun., Silksworth Hall, Sunderland ... ... (N A) Feb. 1897

E.

Edminston, Alex. R., c/o Mrs. Sheffield, 10, Beaconsfield Square, Hartlepool ... ... (E) Jan. 1898

F.

Featherstonhaugh, Albany, 13, Park Place West, Sunderland ... (E) Oct. 1894
Fenton, Frederick, 15, Kent Street, Jarrow-on-Tyne ... ... (S) Mar. 1898
Fitzgerald, Arthur F., 1, Wood Terrace, Westoe. South Shields ... (S) Feb. 1901
Fitzgerald, Junr., Durham Walker, 1, Wood Terrace, Westoe, South Shields ... ... (S) Feb. 1901
Fletcher, Arthur C., 29, Birtley Avenue, Tynemouth ... ... (E) Mar. 1900
Forster, Charles M., Oakfield, Ryton-on-Tyne ... ... (E) Oct. 1898

G.

Gibbons, Norman B., 64, Stirling Road, Trinity, Leith, N.B. ... (E) Feb. 1901
Glahome, John W., 43, North Terrace, Wallsend-on-Tyne... ... (E) Nov. 1899
Gray, Robert Bertram, Burnside Villa, W., Newcastle-upon-Tyne (E) Oct. 1900

H.

Haig, William G., 1, Humbledon View, Sunderland ... ... (S) May 1899
Hamilton, James, Beech House, Mile End, Stockport ... ... (E) Nov. 1897
Hammond, F. Chas., High Street, West Cornforth, R.S.O., Co. Durham ... ... (E) Nov. 1899
Heck, John S., 10, Bristol Terrace, Newcastle-upon-Tyne ... ... (E) Dec. 1899
Hedley, Ralph, Jun., 19, Belle Grove Terrace, Newcastle-upon-Tyne (E E) Dec. 1899
Hepburn, James M., 17, Grosvenor Place, Jesmond, Newcastle-upon-Tyne ... ... (E) Nov. 1895
Hills, Lawrence, 2, Somerset Terrace, East Boldon, Newcastle-upon-Tyne ... ... (S) Nov. 1898
Hutchinson, Wm. G., Rock Lodge, Roker, Sunderland ... ... (S) May 1899
Hutton, John S., Kildale, Clayton Road, Newcastle-upon-Tyne (E) Nov. 1897

J.

James, Matthew C., Jun., 6, Park Terrace. Gateshead-on-Tyne ... (E E) May 1899
James, Wm. E., 6, Park Terrace, Gateshead-on-Tyne ... ... (S) May 1899
Jobling, Vivian, Whickham, Swalwell, R.S.O. ... ... (E) Oct. 1898
Joicey, Edward James, 30, Bewick Road, Gateshead ... ... (E) April 1900

L.

Lee, Hugh Warren, 88, Manor House Road, Jesmond, Newcastle-upon-Tyne ... ... (E) Dec. 1899

		ELECTED.
Lindsay, James D., Fernville, Gosforth, Newcastle-upon-Tyne ...	(E E)	Jan. 1897
Little, Alvin, 39, Leazes Terrace, Newcastle-upon-Tyne	(E)	Mar. 1901
Luhrs, H., 16, Laburnum Avenue, Wallsend-on-Tyne	(E)	Nov. 1899

M.

MacBride, James Douglas, 76, Hillside Avenue, Arlington Heights. Mass., U.S.A.	(S)	Oct. 1900
Mathews, Gordon D., 9, St. Luke's Terrace, Pallion, Sunderland...	(E)	Dec. 1899
McCoull, Cecil, Ovington House, Ovingham, R.S.O., Northumberland	(E)	Oct. 1895
Melville, James, Duke Street, Barrow-in-Furness	(E)	Feb. 1900
Milne, George Murray, 17, East Percy Street, North Shields ...	(S)	Feb. 1898
Morris, David, Haingwood Terrace, Bill Quay-upon-Tyne... ...	(S)	Dec. 1900
Moss, William, 16, Laburnum Avenue, Wallsend-on-Tyne ...	(E)	Jan. 1898
Mudd, Percival Arthur, Greencliffe, Hartlepool	(S)	Oct. 1900
Murray, Athole J., Hassendean, Beech Grove, Newcastle-upon-Tyne	(S)	Nov. 1897

N.

Nelson, George, 54, Cardigan Terrace, Heaton, Newcastle-upon-Tyne	(E)	Jan. 1900
Nesfield, Albert C., 8, Lawton Street, Newcastle-upon-Tyne ...	(E)	Nov. 1898
Nesfield, Arthur, 8, Lawton Street, Newcastle-upon-Tyne... ...	(E)	Nov. 1898
Nichols, George Henry, 30, Denmark Street, Gateshead-on-Tyne	(E)	Oct. 1900
Nixon, John Robert, 4, Bath Terrace, Blyth	(E)	Feb. 1898

O.

Olsen, Hans B., Jun., Wellington Road, West Hartlepool... ...	(E)	Feb. 1895
Owen, Charles E. A., The White House, Old Benwell, Newcastle-upon-Tyne	(S)	Nov. 1898

P.

Patterson, Robt. O., Thorneyholme, Blaydon-on-Tyne	(E)	Jan. 1895
Posgate, James Stephen, Acacia Villa, Darnley Road, Gravesend, Kent	(E)	Nov. 1895
Potts, Arthur W., 9, Beaconsfield Terrace, Gateshead-on-Tyne ...	(E)	Oct. 1898
Potts, Joseph, 14, Moreland Street, West Hartlepool	(E)	Feb. 1898
Potts, Herbert Joseph, 42, Grosvenor Place, Jesmond, Newcastle-upon-Tyne	(E)	Dec. 1899
Potts, John N., 10, Ashburton Crescent, Gosforth, Newcastle-upon-Tyne...	(E)	Dec. 1900

R.

Rappoport, Fred. G., c/o Messrs. Russian Petroleum and Liquid Fuel Co., Baku, Russia	(E)	Mar. 1894
Richardson, Norman Shephard, 15, Wentworth Terrace, Newcastle-upon-Tyne	(E)	Mar. 1901
Robinson, Francis, Willington Rectory, Newcastle-upon-Tyne ...	(E)	Nov. 1897
Robinson, Frank Bertie, 10, Dickinson Crescent, Gosforth, Newcastle-upon-Tyne	(E)	Mar. 1899

ELECTED.

Robson, Geo., Jun., 9, Wellington Terrace, South Shields ... ... (E) Mar. 1899
Routledge, Herbert J., Stapleton House, Jarrow-on-Tyne ... (E E) Mar. 1897

S.

Sanderson, Thomas H., 31, Park Road, Jarrow-on-Tyne ... ... (E) Feb. 1898
Shand, William Lamont, 64, Osborne Road, Newcastle-upon-Tyne (E) Nov. 1895
Smith, John E., 15, Eslington Terrace, Newcastle-upon-Tyne ... (E) Nov. 1897
Spittle, Henry Stuart, 20, Eskdale Terrace, Newcastle-upon-Tyne (E) Oct. 1900
Sprague, Cycil R., B.Sc., 7, Belgrave Terrace, Newcastle-upon-Tyne... ... ... (E) Nov. 1899
Stagg, Albert E., The Rectory, Willington-on-Tyne ... ... (E) Nov. 1899
Steele, Wm. S., 4, Scott Street, Byker, Newcastle-upon-Tyne ... (E) Nov. 1898
Stranbenzee, H. T. V., 15, Jesmond Vale Terrace, Heaton, Newcastle-upon-Tyne ... ... (E) Nov. 1899
Stuart, John, 57, Heaton Park Road, Newcastle-upon-Tyne ... (E) Dec. 1895

T.

Tate, Frank W., 16, Lincoln Street, Gateshead-on-Tyne ... ... (E) Nov. 1898
Taylor, Arthur T., 26, Rye Hill, Newcastle-upon-Tyne ... ... (S) Dec. 1900
Taylor, John Thomas Lloyd, 8, Ravensworth Terrace, Bensham, Gateshead-on-Tyne ... ... (S) Oct. 1900
Temperley, Nicholas R., 4, Carlton Terrace, Low Fell, Gateshead on-Tyne ... ... (E E) Dec. 1898
Thew, Charlton, 15, St. George's Terrace, Newcastle-upon-Tyne ... (E) Dec. 1899
Thompson, John, Wincombles House, Walker-on-Tyne ... ... (S) Nov. 1899
Thornton, E. Fielding, 5, Catherine Terrace, Gateshead-on-Tyne (E) Dec. 1900
Tsimenis, Andrew, Durham College of Science, Barras Bridge, Newcastle-upon-Tyne ... ... (N A) Oct. 1900
Turner, Charles N., 21, Landsdowne Terrace, Gosforth, Newcastle-on-Tyne ... ... (E) April 1896

V.

Vaughan, Wm. A., The Poplars, Gosforth, Newcastle-upon-Tyne... (E E) Jan. 1898

W.

Waddingham, W. H., 42 Lovaine Place, Newcastle-upon-Tyne ... (E) Nov. 1897
Wailes, William C., Jesmond House, Richmond Road, Cardiff ... (E) Nov. 1898
Walker, Gavin Knox, 118, New London Road, Chelmsford, Essex (E) Mar. 1894
Watson, John, 104, Cardigan Terrace, Heaton, Newcastle-upon-Tyne ... ... (S) Dec. 1897
Watson, Kenneth, 3, Rosella Place, North Shields ... ... (E) Mar. 1899
White, Percy M., c/o Messrs. R. & W. Hawthorn, Leslie, & Co., St. Peter's Works, Newcastle-upon-Tyne ... ... (E) Nov. 1899
Williams, Edward, Bradley Terrace, Walker-on-Tyne ... ... (E) Mar. 1899
Wilson, Percy P., 1, Alice Street, Sunderland ... ... (S) Jan. 1896
Winstanley, P. G., 6, Joannah Street, Newcastle Road, Sunderland ... ... (S) Oct. 1898
Wood, Lionel, 4, Simonside Terrace, Heaton, Newcastle-upon-Tyne... ... ... (E E) Nov. 1897

ELECTED.

Woods, Arthur, Mitford House, Wilfred Terrace, Whitley Bay, Northumberland ... ... (E) Nov. 1900

Wotherspoon, William L., c/o Messrs. W. Doxford & Sons, Pallion, Sunderland... ... ... (E) Jan. 1898

Wraith, Herbert O. ... ... (E E) Feb. 1900

Wright, George Hudson, 23 Albury Park Road, Tynemouth ... (E E) Feb. 1896

THE NORTH-EAST COAST INSTITUTION

OF

ENGINEERS AND SHIPBUILDERS.

Constitution and Bye-Laws,

ADOPTED AT A GENERAL MEETING ON THE 4TH MARCH, 1885.

REVISED AT THE CLOSING BUSINESS MEETING HELD ON 4TH MAY, 1887.

RE-REVISED AT THE CLOSING BUSINESS MEETINGS HELD ON 9TH MAY, 1888, 13TH MAY, 1889, 11TH MAY, 1891, 14TH MAY, 1895, AND 13TH MAY, 1898.

CONSTITUTION.

Name.

I.—The NAME of the Association is "The North-East Coast Institution of Engineers and Shipbuilders."

Objects.

II.—The OBJECTS for which the Institution is established are:—The advancement of the science and practice of Engineering and Shipbuilding, and the interchange of ideas and information amongst its members, by means of meetings for the reading and discussion of papers relating thereto, and placing on record its transactions.

III.—The Institution shall consist of Honorary Members, Members, Associates, and Graduates.

Honorary Members.

IV.—HONORARY MEMBERS shall be such distinguished persons as the Council may elect.

Members.

V.—MEMBERS shall be Principals or Principal Managers engaged in Engineering or Shipbuilding; Civil, Military, or Mining Engineers, or Naval Architects; whose subscription shall be Two Guineas per annum: and other persons engaged in the above professions; whose subscription shall be One Guinea per annum.

Associates.

VI.—ASSOCIATES shall be such persons as are not strictly Engineers or Shipbuilders, but are connected with or interested in such pursuits, and are deemed by the Council to be eligible for Associate membership. Their subscription shall be One Guinea per annum.

Graduates.

VII.—GRADUATES may be persons under twenty-four years of age, engaged in study or employment to qualify themselves for any of the above professions. Their subscription shall be Half-a-Guinea per annum.

Life Members and Associates.

VIII.—Any MEMBER may become a LIFE MEMBER by a single payment of Twenty Guineas, or any ASSOCIATE may become a LIFE ASSOCIATE by a single payment of Ten Guineas. All such compositions shall be deemed to be capital moneys of the Institution.

Officers.

IX.—The COUNCIL of the Institution shall be elected from and by the Members, and shall consist of one President, the Past-Presidents, eighteen Vice-Presidents, fifteen Ordinary Members of Council, and an Honorary Treasurer.

Election of Officers. (See Bye-Law No. 11.)

X.—The President and Honorary Treasurer shall be elected annually. Three Vice-Presidents and five Ordinary Members of Council shall be elected annually. The retiring Vice-Presidents shall be those who have been in office for the longest period, and Ordinary Members of Council those who have served three years from their last election.

The President shall be eligible for re-election for a second year; should he be re-elected he shall retire at the conclusion of his second year of office, and shall not again be eligible until after an interval of one year.

The retiring Vice-Presidents shall be eligible for re-election. The retiring Ordinary Members of Council shall not be eligible for re-election to the same office until after an interval of one year, but shall be eligible for election to any other office.

The Honorary Treasurer shall be eligible for re-election annually, or for election to any other office.

Honorary Members' Privileges.

XI.—Honorary Members may attend all the General Meetings, they may read papers, take part in discussions, in voting, in moving and supporting resolutions, in presentation of notices of motion, or in requisitions for Special Meetings, and in the proposition of new members; they shall also receive copies of the Transactions.

Members Privileges.

XII.—Members shall have all the privileges of the Institution as enumerated in the foregoing paragraph, and shall be eligible for office.

Associates Privileges.

XIII.—Associates shall have all the privileges enumerated in paragraph XI. They shall be eligible for office as Ordinary Members of Council.

XIV.—Graduates may attend all the General Meetings, they may read papers, take part in discussions, and support resolutions; they shall also receive copies of the Transactions, but shall not sign proposals for new members, vote, nor be eligible for office. Graduates' Privileges.

XV.—The General Meetings of the Institution shall be held during the months of October to May, inclusive, of each year. General Meetings.

NOTE.—When the word Member is initialled with a capital letter it signifies a member under paragraphs IV. and V., but when initialled with a small letter, it signifies a member of any class of the Institution membership.

BYE-LAWS.

MEMBERSHIP.

1.—Every candidate for admission as a Member, Associate, or Graduate shall be proposed and recommended according to the Form A in the Appendix, in which form the name, usual residence or the place of business, the qualification for, and proposed class of membership of the candidate shall be distinctly specified. Proposals for Graduates must give the date of, and age, last birthday. Candidates for Admission.

The form shall be signed by a Member or Associate of the Institution, as proposer, and by at least other three Members or Associates as supporters, certifying a personal knowledge of the candidate.

The proposal so made shall be submitted to the Council, when, if it be approved, the Chairman shall sign the approbation, which shall be inserted in the notice calling the next General Meeting, when the candidate shall be balloted for, and shall be accepted if three-fourths of the votes are favourable.

2.—Graduates desirous of becoming Members shall be proposed and recommended according to the Form B in the Appendix. Graduates becoming Members.

The proposal so made shall be submitted to the Council, who shall agree to or reject it.

3.—The balloting for membership shall be conducted in the following manner:—Each member shall be supplied by post with a list of the names of the candidates, according to the Form C in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected. These lists may be Balloting for Members.

returned to the Secretary by post, or may be deposited in the ballot-box by the voter in person on entering a meeting at which an election is to take place. The ballot-box will be closed at ten minutes after the advertised time of meeting. The lists shall then be handed over to the Chairman, who shall appoint two Scrutineers to examine them, after which examination the Chairman shall inform the meeting of the result.

Candidates to receive Notice of Election.

4.—Notice of Election as a member shall be sent to the candidate within one week after his election, according to the Form D in the Appendix; but his name shall not be added to the list of Members, Associates, or Graduates of the Institution, until he shall have paid his first annual subscription.

Rejection of Candidates.

5.—In case of rejection of the candidate, no mention thereof shall be made in the minutes, nor shall any notice be given to the unsuccessful candidate.

Subscriptions payable in Advance.

6.—All subscriptions shall be payable in advance, and shall become due on the 1st of August each year. Any Member, Associate, or Graduate, wishing to retire from the Institution shall continue to be liable for his annual subscription until he shall have given formal notice of his retirement to the Secretary, which notice must be given on or before the 31st of August in each year. Application for membership may be made at any time during a Session, and the subscription shall cover the membership up to the 1st of August following.

Receipt of Subscription.

7.—On payment of each subscription the Secretary shall forward to the member an official receipt.

Questions of Privilege.

8.—On question of privilege.—Any person who may be unknown in the meeting shall only be able to claim the privilege in question on proving his membership for the current Session.

Arrears of Subscriptions.

9.- Any member whose subscription is one year in arrear shall be reported to the Council, who shall direct application to be made for it, according to Form E in the Appendix; and in the event of its continuing in arrear until the end of that Session after such application, the Council shall have the power, after remonstrance by letter, according to the Form F in the Appendix of declaring that the defaulter has ceased to be a member.

Power of Council to remove Name from List of members.

10.—The Council may refuse to continue to receive the subscriptions of any member who shall have wittingly acted in contravention of the Regulations of the Institution, or who shall,

in the opinion of the Council, have been guilty of such conduct as shall have rendered him unfit to continue his membership; and the Council may remove his name from the list of members: and such person shall thereupon cease to be a member of the Institution. Notice of such action of the Council shall be forwarded to the person in question, in accordance with the Form G in the Appendix. The reason for such action of the Council shall not be stated to the person expelled, without the sanction of the Council.

OFFICERS.

Election of Officers.

11.—The Annual Election of Officers shall be conducted in the following manner:—The Council shall meet in March or April, and shall arrange a list of nominations, in accordance with the Form H in the Appendix. It shall nominate new names in the place of the retiring Members, and the number of nominations shall be one in excess of the number required in each section of the Council. Such list shall be presented at the General Meeting immediately preceding the last General Meeting of the Session, and any Member present shall be at liberty to nominate additional Members. The list shall show who remain in office throughout the Council, and who are retiring. A copy of this ballot list shall be forwarded to each Member and Associate, together with a complete list of Members of Council, to be filled in, in accordance with the instructions printed in the ballot form, and to be returned to the Secretary to be opened in the presence of the Council, at a Council Meeting which shall be held in April or May, when the scrutiny and counting shall be carried out by the Council. Any Member in voting shall be at liberty to erase any name or names from the list and substitute the names of any other person or persons eligible for each respective office other than those already placed on the ballot list by the Council and Members of the Institution.

Any voting paper returning either more or less than one President, eighteen Vice-Presidents, one Honorary Treasurer, and fifteen Ordinary Members of Council, shall be disqualified for the section or sections in which such errors occur, and the votes shall be lost for the said section or sections. The votes given as President, to a Member who is not elected President, shall count to him as a Vice-President; the votes given as Vice-President, or Treasurer, to persons not so elected, shall count to

them as Ordinary Members of Council, unless they have just completed a term of office in such capacity.

The voting list shall not be sent to any Member and Associate whose subscriptions are more than one year in arrear; nor shall any such Member be nominated on the list. For this purpose, the Secretary shall prepare, previously to the meeting of Council, a list of those Members whose subscriptions are more than one year in arrears.

Ballot to be declared at May Meeting.

12.—The result of the ballot for Officers shall be declared at the Closing Business Meeting, to be held in May, at which meeting general business shall be transacted. At this meeting the newly-elected Officers, after being declared, shall enter into office; and this shall be the last meeting of the Session.

Power of Council to fill up Casual Vacancy.

13.—The Council shall have power to supply any casual vacancy within itself (including any casual vacancy in the office of President), which shall occur between one May Meeting and another; and the Officers so appointed shall retire when the persons whose places they fill would have retired. Vacancies not filled during the year shall be filled at the General Election.

GENERAL MEETINGS.

General Meetings.

14.—The Annual General Meeting shall take place in October, and the Closing Business Meeting in May; each of these meetings shall be held in Newcastle-upon-Tyne. The Ordinary Meetings shall take place in the second week in each following month during the Session, unless otherwise arranged by the Council, and at such hours and places as the Council may determine.

Notice of Meetings.

15.—Seven clear days' notice of every General Meeting, Ordinary or Special, specifying the nature of business to be transacted, shall be given to every member of the Institution.

Special General Meetings.

16.—A Special General Meeting may be convened at any time by the Council, and such meeting shall be convened by the Council whenever such is the declared wish of a General Meeting, or whenever a written requisition, signed by twenty members, specifying the object of the meeting, is left with the Secretary. If, for fourteen days after the delivery of such requisition, a meeting be not convened in accordance therewith, the requisitionists, or any twenty members of the Institution, may convene a Special Meeting in accordance with the requisition. The business discussed at such Special Meetings shall only be that indicated on the notice calling the meeting.

Quorum.

17.—Twenty Members shall constitute a quorum for the purpose of a meeting other than a Special Meeting. Thirty Members shall constitute a quorum for the purpose of a Special Meeting.

Chairman at Meetings.

18.—The President shall be chairman at every meeting, and in his absence, one of the Past-Presidents or one of the Vice-Presidents; or in the absence of these, an Ordinary Member of Council shall take the chair; or if no Member of Council be present and willing to take the chair, the meeting shall elect a Chairman.

Decisions of General Meetings.

19.—The decision of a General Meeting shall be ascertained by a show of hands; or, when five Members or Associates shall demand, or the Chairman may think it desirable, the decision shall be taken by ballot. The manner of counting the votes shall be at the discretion of the Chairman, and an entry in the minutes, signed by the Chairman, shall be deemed sufficient evidence of the decision of a General Meeting. In cases of equality of votes, the Chairman shall have a casting vote; otherwise he shall not vote.

Questions of a Personal Nature in General Meetings.

20.—Questions of a personal nature arising in a General Meeting, shall, if possible, be referred to the Council, otherwise the decision of the meeting shall be taken by ballot on a motion or amendment put to the meeting. The ballot shall be taken by the voters (being Members or Associates) writing "for" and "against" on a slip of paper. The slips shall be folded and collected, and then counted in the presence of the meeting, and the result announced by the Chairman. Should fewer than twenty votes be given, it shall be understood that the question is shelved, and the votes shall be destroyed without being opened.

Transactions of Business, General Meetings.

21.—At every General Meeting of the Institution, the Secretary shall first read the minutes of the preceding meeting, which, on approval, shall be signed by the Chairman; business arising out of these minutes shall then be transacted. The Secretary shall read any notices which may have to be brought before the meeting. Notices of motion may then be given, and other business of the Institution may be attended to; but when a paper is to be read, the foregoing business shall not be extended beyond half-an-hour after the advertised time for commencing the meeting. The paper or papers for the evening shall then be read and discussed.

Dissolving General Meeting.

22.—If within half-an-hour after the time fixed for holding a General Meeting a quorum is not present, the meeting shall be

dissolved, and all matters which might, if a quorum had been present, have been done at the meeting so dissolved, may forthwith be done on behalf of the meeting, by the Council; except the reading or discussion of a paper, which shall not proceed in the absence of a quorum.

Adjourning a General Meeting.

23.—Any General Meeting of the Institution may be adjourned by a vote of the Members and Associates present if there be a quorum; if there be not a quorum, the case shall be met by the preceding paragraph.

Introduction of Friends.

24.—Each member shall have the privilege of introducing one friend to the General Meetings, whose name must be written in the Visitors' Book, together with that of the member introducing him; but if the introducing member be unable to attend the meeting, he may send the name of the visitor to the Secretary. During such portions of any of these meetings as may be devoted to any business connected with the management of the Institution, visitors may be requested by the Chairman to withdraw. This shall be done if five Members or Associates, or both, present request it.

COUNCIL MEETINGS.

Council Meetings.

25.—The Council shall meet before each General Meeting, or on other occasions when the President shall deem it necessary; being summoned in either case by circular, stating the time of meeting, and the business, so far as is known.

Convening Meeting for Expenditure of Funds.

No business involving expenditure of the funds of the Institution (except by way of payment of current accounts) shall be transacted at any Council Meeting, unless the circular gives six clear days' notice, and states the business.

Discussions of Personal Character.

All discussions of a personal character in the Council shall be considered and treated as being strictly confidential.

Regulation of Proceedings.

26.—The Council may regulate its own procedure, and delegate any of its powers and discretions to any one or more of its number.

Chairman and Quorum.

The President shall, *ex officio*, be chairman of all Council Meetings, and in his absence one of the Past-Presidents or one of the Vice-Presidents shall take the chair; or in the absence of these, one of the Ordinary Members of Council shall be elected to take the chair. Five members of Council, including the Chairman, shall form a quorum.

Sub-Committees.

In the appointment of Sub-Committees, the Council shall determine the number which shall form a quorum in each case,

and shall appoint a Chairman. These regulations shall not affect the Finance Committee.

Sub-Committees.

27.—The Council may appoint Committees either from itself, or with the assistance of persons outside, for the purpose of transacting any special business, or of investigating specific objects connected with the work and interests of the Institution.

Sub-Committees.

28.—All Committees or Sub-Committees shall be appointed by the Council, and shall be subject to that body, and shall report to it. The Council shall act upon these reports or recommendations as it may think best. The President shall, *ex officio*, be a member of all Committees.

Communication to Council.

29.—Any member may by communication addressed to the Secretary petition the Council to lay before a General Meeting of the Institution the contents of any letter which shall in a short, concise, and clear manner draw the attention of the Institution to public matters of importance in connection with legislation proposed by any governing body in reference to the construction of ships, machinery, or the working of the same, so that members may by their scientific and practical knowledge demonstrate the soundness or otherwise of the proposed measure.

Invitation to Strangers.

30.—The Council may invite to General Meetings or to Council Meetings any person or persons whose presence and assistance it may desire, and strangers so invited shall be permitted to take part in the proceedings, but not to vote.

Secretary and Treasurer's Duties.

31.—The Secretary, who shall also act as Treasurer, shall be appointed by and act under the direction and control of the Council, and shall be paid such salary as the Council shall determine. He shall attend all meetings, Council and General, and shall take minutes of the proceedings, and enter them in proper books provided for the purpose. He shall write the correspondence of the Institution and Council, read minutes and notices at meetings, report discussions, and, if required by the Council, prepare papers for reading and publication, and read papers and communications at the meetings. He shall receive all payments due to the Institution, and shall bank the cash in hand whenever it amounts to ten pounds. The bank shall be determined by the Council and the banking account shall be in the names indicated in connection with the Finance Committee. He shall keep a cash account book, general and detail, which shall on all occasions be open to inspection by the Finance

Committee or by the Council. He shall keep a register of the names of members, so arranged as to distinguish all members whose subscriptions are in arrear. He shall also perform whatever other duties are indicated in the Bye-Laws of the Institution as appertaining to his department; and shall remain in office during the pleasure of the Council. He shall not vote on any resolution.

32.—The following Sub-Committees shall be appointed annually at the first meeting of the Council in each Session:—

Finance Committee.

(1) A Finance Committee, to consist of seven persons, viz.: one Past-President or Vice-President, who shall be Chairman; five Members of Council, and the Honorary Treasurer of the Institution; three of whom shall form a quorum. The Treasurer shall be empowered to pay all amounts due from the Institution which are under two pounds. All amounts of two pounds and upwards shall be paid by cheque, signed by the Chairman of the Finance Committee (or in his absence, by the President or a Past-President), the Secretary and the Honorary Treasurer. (2) A Reading Committee, to consist of six members of Council. No member who has served on this Committee for three years in succession shall be eligible for re-election until after an interval of one year. (3) A Library Committee, in accordance with Library Rules, Nos. 1 and 3. (4) A Graduates' Award Committee to consist of five members.

Payment of Accounts.

Reading and Library Committees.

TRANSACTIONS.

Papers to be submitted to Council.

33.—All papers shall be forwarded to the Secretary at least five clear weeks before the proposed date of reading. The Secretary shall submit them for approval to the Council, and on their general approval they shall be handed to the Reading Sub-Committee, three of whom at least, shall read the paper through. The Reading Sub-Committee shall be at liberty to strike out any parts which, in their opinion, ought not to be read. They may also make any suggestions to the author as to points which might with advantage be inserted or altered. A synopsis of the subject-matter of each paper shall be forwarded to the Secretary, by the writer, for insertion in the circular convening the meeting at which the paper is to be read.

Reading Sub-Committee.

Synopsis of Papers.

Printing Transactions.

34.—The papers read, and the discussions on them, or such portions of them as the Council shall select, shall be printed for

distribution among the members, each of whom shall receive a copy. These Transactions shall be edited by the Secretary, in accordance with instructions of the Council, who shall have power to omit parts of discussion which may be foreign to the subject, or which it may be deemed undesirable to retain. Each paper shall bear the date on which it was read in General Meeting.

Copy of Papers supplied to members before reading, etc.

35.—Copies of papers to be read during any Session will be sent seven days before the date of reading to members who shall have applied to the Secretary for them, in writing, at the commencement of the Session. The discussion on a paper shall not be considered closed on the evening on which it is read, but shall be open for renewal at a subsequent meeting, prior to the reading of the paper set down for that date.

Proofs sent to members for Correction.

36.—The Secretary shall send to each speaker as soon as possible after a General Meeting a copy in manuscript of the speaker's own remarks for correction. This copy must be returned to the Secretary within four days. A printed proof will also be sent to each speaker for further revision; this must be returned to the Secretary within three days, otherwise it will be deemed correct, and printed off after receiving verbal corrections.

Liberty to Print Explanatory Notes.

37.—The Council shall be at liberty to print as Transactions, either with the papers and discussions or separately, explanatory notes, etc., communicated after the reading or discussing of a paper. Such communications must be approved by the Reading Committee, and shall bear the date on which they shall have been received by the Secretary.

Institution not responsible for statements.

38.—The Institution shall not be held responsible for the statements and opinions advanced in any of the papers which may be read, or in the discussions which may take place at the Meetings of the Institution.

Copies of Transactions to be sent to members.

39.—Twenty copies of each paper and discussion shall be presented to the author of the paper, for private use, and one copy shall be sent to each member. When a paper is prepared by two authors, fifteen copies shall be presented to each. Duplicate copies of parts of the Transactions mislaid or lost by members cannot be supplied to them, except as provided for in Bye-Law 42.

Transactions not supplied to members in Arrears.

40.—The Transactions shall not be supplied free to members whose subscriptions are unpaid.

Members not to receive Transactions till after First Payment.

41.—Any member elected at any time between the Annual General Meetings shall be entitled to copies of all the Transactions issued during the Session to which his first subscription applies; but not until the subscription has been paid.

Transactions the Property of the Institution.

42.—The Transactions of the Institution shall be the exclusive property of the Institution, and shall be published only by the authority of the Council. Additional copies of papers required by authors for their private use can only be procured from the Secretary, at prices fixed by the Council from time to time, and these copies must contain the whole of the discussion following the papers, and be bound in the usual cover, with the addition of the following words:—"By permission of the Council," and "Excerpt Minutes of Proceedings." Duplicate volumes and copies of parts of the Transactions, if in print, can also be obtained from the Secretary, and shall be sold only by him, in such manner and at such prices as the Council shall have fixed.

Rule of Discussion.

43.—During a discussion upon any paper, no person shall be at liberty to speak more than once (except by way of explanation), nor for a longer period than ten minutes.

ACCOUNTS, &c.

Accounts.

44.—The Council shall present the yearly accounts (up to the 31st of July preceding) at the Annual General Meeting in October of each year, after they have been audited by a professional Accountant, appointed by the members at the Closing Business Meeting in May.

Trustees.

45.—The capital, stock, and funds of the Institution shall be vested in the names of three Trustees, to be elected from time to time as vacancies occur by the members of the Institution at a General Meeting called for that purpose. All mortgages and other securities shall be taken in the names of such Trustees; and on any new appointment the funds shall vest in the newly-appointed Trustee or Trustees jointly with the continuing or remaining Trustee or Trustees.

Investment of Funds.

46.—The Finance Committee may, with the consent of the Council, invest in the names of the appointed Trustees of the Institution any moneys not immediately required for the purposes of the Institution, in or upon any approved securities.

ALTERATIONS TO CONSTITUTION AND BYE-LAWS.

47.—Alteration in or addition to the Constitution and Bye-Laws may be made only by resolution of the members at the

Closing Business Meeting in May, after notice of the proposed alteration or addition has been announced at the previous General Meeting.

The resolution may be modified by the Council meanwhile, should they so desire; but in this case it shall be read at the Closing Business Meeting in May in its original form before it is proposed in the amended form.

Such resolutions shall be stated in the notice calling the intervening Council Meeting, and also in the notice calling the Closing Business Meeting in May.

Vote by Proxy.

Any member unable to be present at the meeting at which such alterations are to be considered, but who is nevertheless desirous of recording his opinion thereon, shall be allowed to vote by proxy, such proxies shall be in Form J in the Appendix, which may be had on application to the Secretary, and may be used by any member present at the meeting on behalf of the absent member, and counted by the Chairman as of equal value with votes given in the manner provided in Bye-Law 19.

THE GOLD MEDALS.

RULES.

(Revised at Council Meeting held on 15th April, 1901.)

1.—That papers read by members of the Council shall be eligible for the Gold Medals' Award.

2.—That the medals shall be awarded by the vote of the Council given at a meeting of the Council at which the business has been specially noted on the circular convening the meeting.

3.—That when the Council proceeds to award the medals, authors of papers who are members of the Council shall not be present nor vote at such Council meetings.

4.—If at the meeting convened the Council is unable to agree, or considers it desirable, the matter may be deferred for consideration at a future meeting.

5.—That the medals shall be awarded annually, provided the papers are, in the opinion of the Council, worthy of the award, but not otherwise. Papers by authors who have already received a gold medal shall not be eligible for a medal till after the expiration of six years from the date of the previous paper for which the medal was awarded.

APPENDIX TO BYE-LAWS.

FORM A. (BYE-LAW 1.)

Name (in full)
Profession or Occupation and where Employed
Address .
being desirous of admission into the North-East Coast Institution of Engineers and Shipbuilders, we, the undersigned, propose and recommend that he shall become*
thereof. We know him to be†
and eligible for the proposed membership.

* A Member, Associate, or Graduate.

† A Principal, Manager, or Draughtsman, etc. See Articles V., VI., and VII. of Constitution.

	FROM PERSONAL KNOWLEDGE.	SECTION OF MEMBERSHIP.
Proposed by		
Supported by Three Members or Associates.		

Dated this day of

(*When a Graduate is proposed the age last birthday should be stated.*)

FORM B. (BYE-LAW 2.)

A. B. [Christian Name, Surname, Occupation, and Address in full] being at present a Graduate of the North-East Coast Institution of Engineers and Shipbuilders, and upwards of twenty-four years of age, and being desirous of becoming a Member of the said Institute, we, the undersigned [Members or Associates], recommend him, from *personal knowledge*, as a person eligible for the proposed Change of membership, because—

(*Here specify distinctly the Qualifications of the Candidate according to the spirit of the Rules of the Institution.*)

Signed
Three [Members or Associates.]

Dated this day of 19

FORM C. (BYE-LAW 3.)

BALLOTING PAPER FOR MEMBERSHIP.

The Council having considered the recommendations for Membership of the following gentlemen, present them to be balloted for, viz.:—

MEMBER, ASSOCIATE, OR GRADUATE.	OCCUPATION.	ADDRESS.	NOMINATED BY.	SUPPORTED BY THREE MEMBERS OR ASSOCIATES.

Strike out the names of such persons as you desire shall *not* be elected, and forward the list by post to the Secretary, or personally place it in the ballot-box at the Meeting.

FORM D. (BYE-LAW 4.)

SIR,—I am directed to inform you that on the day of you were elected a of the North-East Coast Institution of Engineers and Shipbuilders, but, in conformity with Bye-Law 4, your election cannot be confirmed, nor your name be added to the roll of membership, until you have paid your first annual subscription, the amount of which is £ : : , or, at your option, the Life Composition of £ : : .

Payment may be made to the Treasurer, Mr._____

Address_____

I am, Sir,

Yours faithfully,

Secretary.

Dated 19

N.B.—In case of a Graduate, strike out "*or, at your option, the Life Composition of* £ : : "

FORM E. (BYE-LAW 9.)

SIR,—I am directed by the Council of the North-East Coast Institution of Engineers and Shipbuilders to draw your attention to Bye-Law 6, and to remind you that the sum of £ of your annual subscriptions remains unpaid, and that you are in consequence in arrear of subscription.

I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Rule above referred to.

I am, Sir,

Yours faithfully,

Secretary.

FORM F. (BYE-LAW 9.)

SIR,—I am directed by the Council of the North-East Coast Institution of Engineers and Shipbuilders to inform you that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-Law 9, the Council have determined that unless payment of the amount (£) is made previous to the day of next, they will proceed to declare that you have ceased to be a member of the Institution.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, Sir,

Yours faithfully,

Secretary.

FORM G. (BYE-LAW 10.)

SIR,—I am directed by the Council of the North-East Coast Institution of Engineers and Shipbuilders to inform you that they feel it their duty to advise you to withdraw from the Institution, or otherwise they will be obliged to act in accordance with Bye-Law 9 (or 10, as the case may be).

I am, Sir,

Yours faithfully,

Secretary.

FORM H. (BYE-LAW 11.)

BALLOTING LIST.

PRESIDENT.—ONE NAME only to be returned, or the vote will be lost.

——— President for the current year (eligible for re-election.)*

——— } New Nominations, from whom to select ONE.

VICE-PRESIDENTS.—EIGHTEEN NAMES only to be returned (including the fifteen who remain in office), or the vote will be lost.

——— } Fifteen Vice-Presidents remaining in office. These do not require to be voted for at this election, as their term of service has NOT yet expired.

——— } Three Vice-Presidents retiring, eligible for re-election.

——— } New Nominations, from whom to select THREE.

TREASURER.—ONE NAME only to be returned, or the vote will be lost.

——— Treasurer for the current year, eligible for re-election.

——— } New Nominations, from whom to select ONE.

ORDINARY MEMBERS OF COUNCIL.—FIFTEEN NAMES only to be returned, including the ten who remain in office.

——— } Ten Ordinary Members of Council remaining in office. These do not require to be voted for at this election, as their term of service has NOT yet expired.

——— } Five Ordinary Members of Council retiring, and NOT eligible for re-election.

——— } New Nominations, from whom to select FIVE.

* To be crossed out before issue when the President is not eligible for re-election.

N.B.—(*a*) The names of those who remain in office will be counted in the total number required without being re-written by the voter.

(*b*) Any list having either MORE or LESS than the required number of names voted for in any section will be disqualified for that section.

(*c*) Votes as President for a person who is not elected will count for him as a Vice-President.

(*d*) Votes as Vice-President, or Treasurer, for persons not so elected, will count for them as Ordinary Members of Council, unless they have just completed a term of office in that capacity.

(*e*) This list, duly filled in, may be returned to the Secretary by post, or handed to him, so as to be on the Council table before the commencement of the scrutiny, which is appointed to take place in the Council Room, at 8 p.m., on 19

(*f*) A copy of this list shall be posted at least Seven Days previous to the Annual Meeting to every Member and Associate, who may erase any name or names from the list and substitute the name or names of any other person or persons eligible for such respective offices, but the number of persons on the list after such erasure or substitution must not exceed the number to be elected to the respective offices.

Secretary.

FORM J. (BYE-LAW 45.)

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

FORM OF PROXY.

FOR VOTES ON ALTERATIONS TO CONSTITUTION OR BYE-LAWS.

I,....., being [an Honorary Member, Member, or Associate] of the above Institution, do hereby appoint Mr..... who is [an Honorary Member, Member, or Associate] of the same Institution, to act as my Proxy, and record my Vote at the General Meeting of the Institution, to be held on the... .....day of ....., 18....., and at any adjournment thereof.

Signature.....

Address.....

.....

.....*Secretary.*

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

Supplementary Bye-Laws Relating to the Graduate Section.

I.—The Graduate Section shall be controlled by the General Bye-Laws of the Institution, and the following Bye-Laws are supplementary to these.

This Section shall be open to all Members of the Institution who are under twenty-six years of age, who shall be at liberty to express their views upon any subject brought before the General Meetings of the Section.

Officers by Ballot.

II.—The Officers of the Section shall be elected from and by the Graduates, in accordance with the Form given in the Appendix, and shall consist of one Chairman, one Honorary Secretary, and seven Committee-men. The Committee shall have power to select one of its members to act as Assistant Honorary Secretary if required.

Election of Officers.

III.—(*a*) The Officers shall be elected annually, and shall all be eligible for re-election until the age limit is reached.

Rider to General Bye-Law No. 11.

(*b*) Any voting paper returning either more or less than one Chairman, one Honorary Secretary, and five Committee-men shall be disqualified.

General Meetings.

IV.—The Annual General Meeting shall take place as early as possible after that of the Institution in the month of October, and the Closing Meeting shall be held prior to the Closing Business Meeting of the Institution in May.

Special General Meetings.

V.—A Special General Meeting may be convened at any time by the Committee. The business discussed at such Special Meetings shall only be that indicated on the notice calling the meeting.

Quorum.

VI.—Nine Members shall constitute a quorum for the purpose of a General Meeting.

Excursions.

VII.—Excursions shall be arranged during the Session as the Committee may find expedient. Any Graduate wishing to intro-

duce a friend at such excursions must submit the name of his friend to the Committee at least three clear days before the date of the excursion.

Seven clear days' notice of every excursion shall be given to every Member of the Graduate Section.

COMMITTEE MEETINGS.

Committee Meetings.

VIII.—The Committee shall meet at as early a date as possible after the holding of a General Meeting, and on other occasions when the Chairman shall deem it necessary, being summoned in either case by circular, stating the time of meeting and the business so far as is known. All discussions of a personal character in the Committee shall be considered and treated as being strictly confidential.

Four members of Committee, including the Chairman, shall form a quorum.

Duties of Hon. Secretary.

IX.—The Honorary Secretary shall act under the direction and control of the Committee. He shall attend all Meetings, Committee and General, and shall take minutes of the proceedings and enter them in proper books provided for the purpose. He shall write the correspondence of the Graduate Section and Committee (excepting that arranging for excursions, which shall be arranged by the Secretary of the Institution). He shall keep a stamp account book, which on all occasions shall be open to the inspection of the Secretary of the Institution.

PAPERS.

Synopsis of Papers to be read.

X.—The author of a paper shall forward to the Honorary Secretary, at least fourteen days before the date of the reading of the paper, its title and a synopsis of the contents; a copy of the synopsis to be forwarded to every Graduate, together with the notice convening the meeting at which the paper is to be read.

Copies of Papers to be forwarded to the Secretary of the Institution.

XI.—After the reading of a paper a copy must be forwarded to the Secretary of the Institution in time to be placed before the Graduate Awards Committee. This copy, if deemed necessary by the Council, shall become the property of the Institution, and be placed upon the shelves in the Library. These copies, together with any sketches accompanying them, shall be written upon paper of uniform size.

APPENDIX.

GRADUATES' BALLOTING LIST.

CHAIRMAN.

*——— (E)
——— ( ) } Nominations from whom to select ONE.

HON. SECRETARY.

*——— (E)
——— ( ) } Nominations from whom to select ONE.

COMMITTEE.

*——— (S)
*——— (EE)
*——— ( )
——— ( )
——— ( )
——— ( ) } Nominations from whom to select FIVE.

NOTES.

1.—Any list having either more or less than the required number of names will be disqualified.

2.—All voting papers must be returned to the Secretary of the Institution on or before the day of , 19 .

3.—No signature must be put on this paper.

4.—* Signifies a member of the old committee.

5.—(E) Denotes Engineer; (EE) Electrical Engineer; (S) Shipbuilder.

6.—A copy of this list shall be posted, at least fourteen days previous to the Closing Meeting of the Session, to every Graduate, who may erase any name or names from the list and substitute the name or names of any other person or persons eligible for such respective offices, but the number of persons on the list after such erasure or substitution must not exceed the number to be elected to the respective offices.

7.—Votes as Chairman or Hon. Secretary, for persons not so elected, will count for them as members of committee.

THE LIBRARY AND READING ROOM RULES.

Committee.

1.—The Library and Reading Room shall be managed by a Committee, called the Library Committee, who shall have charge of all books, papers, specimens, etc., which may belong to the Institution. It shall consist of five members of the Institution, of whom at least two shall be members of Council.

Property.

2.—The books and other property of the Library shall be vested in the Trustees appointed by the Institution.

Appointment of Committee.

3.—The Library Committee shall be appointed annually, at the first meeting of the Council in each Session. No member who has served on the Committee for three years in succession shall be eligible for re-election until after an interval of one year. The Chairman shall be elected by the Council.

Librarian.

4.—The Secretary of the Institution shall be Librarian, and shall also act as Secretary to the Library Committee. Three members of the Committee shall form a quorum.

Duties of Committee.

5.—The Library Committee shall be responsible for the binding and purchasing of books, periodicals, papers, etc., and for the expending of all money voted by the Council for its use. It shall appoint an attendant who shall act as Assistant Librarian. It shall make Rules for the management of the Library, subject to the approval of the Council, and present an annual report to the first meeting of the Council held after the annual scrutiny of the books referred to in Rule No. 13.

Hours of Opening and Closing, etc.

6.—Except when closed by special order of the Library Committee, or when the Council is sitting, the Library and Reading Room shall be open for consulting, borrowing, or returning books, every week day as follows:—

FROM OCTOBER 1ST TO MAY 31ST.

Monday ... Tuesday ... Wednesday ... Friday ...	From 10 a.m. to 8 p.m.
Thursday ...	From 10 a.m. to 1 p.m.
Saturday ...	From 10 a.m. to 1 p.m. and from 3 p.m. to 9 p.m.

FROM JUNE 1ST TO SEPTEMBER 30TH.

Monday ... Tuesday ... Friday ...	From 10 a.m. to 5 p.m.
Wednesday ...	From 10 a.m. to 8 p.m.
Thursday ...	From 10 a.m. to 1 p.m.
Saturday ...	From 10 a.m. to 1 p.m. and from 6 p.m. to 9 p.m.

The Rooms will be closed on Christmas Day and the day following; New Year's Day and the day following; Good Friday and the day following; Monday and Tuesday in Easter week and Whit week; on Tuesday, Wednesday, Thursday, Friday and Saturday in the Race week of June; and from the fourth Saturday in July to the second Saturday in August inclusive, as mentioned in Rule No. 13.

Lending of Books.

7.—Books shall not be lent to any persons except Members, Associates, or Graduates of the Institution, but a person entitled to borrow a book may send a messenger with a signed order for it.

Visitors.

8.—Each member shall be entitled to introduce a friend to the Reading Room, whose name shall be written in the Visitors' Book, together with that of the member introducing him.

Reference Books.

9.—The books marked with an asterisk in the Catalogue shall be kept only for consultation in the Library, and shall not be lent. Pending the preparation of a Catalogue, the Librarian shall be instructed by the Committee as to which books shall be withheld from circulation.

Unbound Books.

No periodicals, magazines, or pamphlets shall be issued for circulation until after they have been bound and added to the Lending Library.

Register of Books Lent, etc.

10.—The Librarian shall keep a register in which he himself or the attendant shall enter the titles of the books lent, the date of lending, the name of the borrower, and the date of the return of the book to the Library. The borrower of the book or the bearer of his order shall initial the entry of such borrowing, and the Librarian or the attendant shall initial the date of the return of the book.

Number Lent to each member.

11.—No person shall borrow or have in his possession at one time more than two volumes belonging to the Library.

Return of Books.

12.—No member shall retain a book longer than fourteen days, excluding the day of issue. He shall be responsible for the safe return of the book, and if it be damaged or lost he shall make good the cost of such damage or loss.

Yearly Inspection of Books.

13.—All books belonging to the Library shall be called in for inspection, and the lending out of books shall be suspended from the fourth Saturday in July to the second Saturday in August inclusive, in each year, and members shall be required by notice to return all books in their hands before the period mentioned.

Fine.

Members failing to comply with this injunction shall pay a fine of two shillings and sixpence.

14.—Members are requested, when in the Reading Room or Library, to contribute to the general comfort by carefully abstaining from loud talking and noise of any kind. Smoking is not permitted in the Library.

Members in Arrears.

15.—Any member being twelve months in arrears with his subscriptions to the Institution shall not be at liberty to use the Library or Reading Room after the commencement of the first Session following.

N.B.—The foregoing Rules may be amended at any time by the Library Committee with the sanction of the Council.

LIBRARY CATALOGUE.

CATALOGUE OF TRANSACTIONS, PERIODICALS, AND BOOKS IN LIBRARY

(ALL BOOKS MARKED * ARE FOR CONSULTATION ONLY, SEE RULE 9.)

(1) TRANSACTIONS OF LEARNED SOCIETIES.

American Society of Civil Engineers, New York, 1893, Parts I. and II.
American Society of Mechanical Engineers, New York City, Vol. I. to date.
American Society of Naval Engineers, Navy Department, Washington, Vol. I. to date.
Canadian Society of Civil Engineers, Montreal, Canada, Vol. I. to date.
Cleveland Institution of Engineers, Middlesborough, 1889 to date.
Engineering Association, Sydney, New South Wales, Australia, Vol. I. to date.
Engineers and Shipbuilders in Scotland, Glasgow, Vol. III. to date.
Genio Civile, Roma, Vol. XXII. to date.
Hull and District Institution of Engineers and Naval Architects, Hull, Vol. I. to date.
Illustrated Official Journal of Patents, London, July 1888 to date.
Institution of Civil Engineers, London, Vol. XXX. to date.
Ipswich Engineering Society, Ipswich, Vol. I.
Iron and Steel Institute, London, 1885 to date.
Institution of Junior Engineers, London, 1884 to date.
L'Association Technique Maritime, Paris, Vol. I. to date.
Liverpool Engineering Society, Liverpool, Vol. I. to date.
Liverpool Polytechnic Society, Liverpool, 1887 to date.
Manchester Association of Engineers, Manchester, 1883 to date.
Marine Engineers' Institute, Essex, Vol. I. to date.
Mechanical Engineers, London, 1885 to date.
Midland Institute of Mining, Civil, and Mechanical Engineers, Barnsley, 1884 to date.
Naval Architects' Institution, London, Vol. I. to date.
North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne, Vol. XXXIV. to date.
North-East Coast Institution of Engineers and Shipbuilders, Vol. I. to date.
North-East Coast Institution of Engineers and Shipbuilders, MS. Papers read before the Graduate Section, Session 8 to date.
Nova Scotian Institute of Science, Canada, 1890 to date.
Philosophical Society of Glasgow, Vol. XIX. to date.
Royal Dublin Society, Dublin, Vol. III. to date.
Schiffbautechnischen Gesellschaft, Berlin, Vol. I.
Société des Ingénieurs, etc., de Liége, 1885 to date.
Société des Ingénieurs, Civil de France, Paris, 1880 to date.
Société Scientifique de Marseille, Vol. I. to date.
Society of Arts, London, Vol. XXXVII. to date.
Society of Engineers, London, 1884 to date.
Society Naval Architects and Marine Engineers, New York, Vol. I. to date.
South Wales Institution of Engineers, Cardiff, 1884 to date.
United States Naval Institution, Annapolis, Maryland, U.S. of America. 1886 to date.
Western Society of Engineers, Chicago, Vol. I. to date.

(2) Technical Journals and Periodicals.

American Machinist, Vol. XV. to date.
Cassier's Magazine, Vol. VII. to date.
Electrical Engineer, London, Vol. III. to date.
Electrical Review, London, Vol. XXIV. to date.
Engineering, London, Vols. IV., V., and VI., XX. and XXI., XXXIV. to date.
Fairplay, 1895 to date.
Fielden's Magazine, Vol. II. to date.
Indian and Eastern Engineer, Calcutta, British India, Vol. VII. to date.
Indian Engineering, Calcutta, British India, Vol. III. to date.
Industries, London, Vol. I. to Vol. XXIV.
Iron, London, 1888 to 1891.
Iron and Coal Trades Review, London, Vols. XXXVI. and XXXVII. only.
Journal de La Marine le Yacht, 1892 to date.
Marine Engineering, New York.
Marine Engineer, London, Vol. VII. to date.
Mechanical World, Manchester, 1886 to date.
Revista Marittima, Rome, Vol. I. to date.
Shipping World, London, Vol. IV. to Vol. XIII.
Stahl und Eisen, Düsseldorf, Vol. IX. to date.
Steamship, Leith, Vol. I. to date.
The Electrician, London, Vol. XXX. to date.
The Engineering Magazine.
The Engineer, London, 1882 and 1885 to date.
The Mechanical Engineer.
The Mechanics' Magazine, 1864-1866 (3 vols.).
The Practical Engineer, Manchester, Vol. I. to date.
The Practical Mechanics' Journal, London. 1863 to 1870 (4 vols.).
Transport, London, Vol. II. to Vol. VI.

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(3) General.

(*a*) *Engineering and Mechanical.*

Applied Mechanics	Prof. Rankine	1888
Do.	J. H. Cotterill	1890
Do.	Perry	1897
Artillery	E. N. Lloyd & A. G Hadcock	1893
Boilers and Boiler Making	N. P. Burgh	1873
Boilers, their Construction and Strength...	T. W. Traill	1888
Boilers, Heat Efficiency of Steam	B. Donkin	1898
Boilers and Furnaces	Barr	1899
Boilers, Marine (2 copies)	Bertin & Robertson	1898
Boilers, Steam	R. Wilson	1879
Do.	R. H. Thurston	1888
Boilers, Experiments on Steam	Donkin & Kennedy	1897
Boiler, Management and Construction of Marine ...	C. E. Stromeyer	1893
Bridge Construction	T. C. Fidler	1887
Bureau of Steam Engineering (U.S.A.), Report of (6 vols.) ...		1889
Bureau Veritas—Report on Steel		1878
Castings and Founding, Practical Treatise on	N. E. Spretson	1892
Centrifugal Pumps	J. Richards	1894

Civil Engineering	Prof. Rankine	1889
Commercial Management of Engineering Works	F. G. Burton	1899
Constructive Steam Engineering	Whitham	1893
Development and Transmission of Power	Unwin	1893
Elements of Machine Design (2 vols.)	Unwin	1891
Engine and Boiler Trials	R. H. Thurston	1890
Engineering Facts and Figures (2 vols., 1863 and 1864)	A. B. Brown	1865
Engineering Popularly and Socially Considered (2 copies)	J. W. C. Haldane	1890
Engineer's Handbook	T. Reed	1889
Engineer's Guide	T. Reed	1892
Engineers' Price Book	Spon	1892-93
Engineer's Sketch Book	T. W. Barber	1897
Entropy, Diagram, The	J. Boulvin	1898
Flameless Explosives Committee, Report of the	A. C. Kayll	1896
Friction and Lost Work in Machinery and Millwork	R. H. Thurston	1889
Gas Engine	D. K. Clark	1890
Gas and Petroleum Engines	Robinson	1891
Gas, Air, and Oil Engines (2 copies)	B. Donkin	1900
Graphic Statics, Principles of	G. S. Clark	1888
Heat, Treatise on	T. Box	1888
Heat: A Mode of Motion	J. Tyndall	1887
Heat in its Mechanical Applications		1885
Hydrology, Manual of	W. Beardmore	1872
Hydraulic Power and Hydraulic Machinery		1887
Hydraulic Motors	Bodmer	1889
Iron Bridge Construction (2 vols.)	W. Humber	1870
International Maritime Congress		1893
Iron Roofs	Prof. Rankine	1888
Locomotives, Modern		1897
Locomotive Engineering, Manual of	Pettigrew & Ravensham	1899
Locomotives, Construction of Modern	G. Hughes	1894
Locomotive Construction, Modern	Meyer	1894
Locomotive Mechanism	H. C. Reagan	1896
Lubrication and Lubricants	L. Archbutt & R. M. Deeley	1900
Machine Drawing and Design	Low & Bevis	1893
Machinery and Millwork	Prof. Rankine	1887
*Mackrow's Pocket Book		1892
Manual of Marine Engineering (2 copies)	A. E. Seaton	1889
Manufacture of Iron and Steel, Principles of	I. L. Bell	1884
Marine Engineering (2 vols.)	W. H. Maw	
*Marine Engineers' Pocket Book	Seaton	1894
Marine Propellors (3 copies)	S. W. Barnaby	1891
Marine Steam Engine (2 copies)	R. Sennett	1885-98
Materials of Engineering (3 vols.)	R. H. Thurston	1884
Mechanical Draft	B. F. Sturtevant	
Mechanical Engineering, Text Book on	W. Lineham	1895
Mechanical Engineers' Reference Book	N. Foley	1891
Mechanical Graphics	G. Halliday	1889
Mechanical Text Book	Prof. Rankine	1884
Mechanician, The	Knight	1888
Mechanics Applied to Engineering	Goodman	1899
Mechanics of Machinery (2 copies)	Kennedy	1886

Metallurgy of Iron, Treatise on	H. Bauerman	1890
Metallurgy of Steel	H. M. Howe	1890
Metallurgy, Elements of	Phillips & Bauerman	1891
Metals: Their Properties and Treatment	C. L. Bloxham	1885
Mill Gearing, etc.	T. Box	1888
Modern French Artillery	Dredge	1892
Modern Marine Engineering (2 vols.)	N. P. Burgh	1872
Modern Foundry Practice	J. Sharp	1900
*Pocket Book on Boilers	T. W. Traill	1888
Pumping Machinery	Barr	1893
Pumping Machinery	H. Davey	1900
Rules and Tables	Prof. Rankine	1889
Rules, Tables, and Data for Mechanical Engineers	D. K. Clark	1890
Railway Construction	Mills	1898
Screw Propeller	W. Bourne	1867
Slide Valve	N. P. Burgh	1868
Slide Valve	C. W. MacCord	1897
Slide Valves and Eccentrics, Treatise on	C. W. MacCord	1883
Steam and the Steam Engine, Text Book on	A. Jamieson	1889
Steam Engine	G. C. V. Holmes	1890
Do. (4 vols.)	D. K. Clark	1890
Do.	J. H. Cotterill	1890
Do.	J. A. Ewing	1892
Steam Engines, Pumps, Boilers, etc., Notes on	D. H. Morton	1895
Steam Engine Design	Whitham	1898
Steam Engine	Prof. Rankine	1888
Steam Engine and the Indicator	Le Van	1890
Strains in Structures	G. A. T. Middleton	1889
Strength of Materials	T. Box	1888
Do. do.	Unwin	1888
Strength of Iron Parts of Steam Machinery	Van Buren	1869
Strength of Beams and Columns	Cousin	1889
Structures, Design of	Anglin	1891
Testing Materials, Handbook of (2 vols.)	A. Martens	1899
Testing Materials of Construction	W. C. Unwin	1888
Theory of Stresses	B. B. Stoney	1886
Twenty Years with the Indicator	T. Pray	1899
Turbine, The	W. Cullen	1871
Valve Gears	J. F. Klein	1884
Valves and Valve Gearing	C. Hurst	1897
Wire, Its Manufacture and Uses	J. B. Smith	1891

(*b*) *Shipbuilding, etc.*

Annals of Lloyd's Register		1884
British Corporation for the Survey and Registry of Shipping	Glasgow	1893
Bureau Veritas Register of Shipping		1887
From Keel to Truck	H. Paasch	1885
German Lloyd's International Register of Shipping		1891
German Lloyd's Rules and Regulations		1891
Illustrated Marine Encyclopedia	H. Paasch	1890
International Congress of Navigation, Report of		1898

International Marine Congress (4 vols.), viz.		
Engineering (2 vols.)		1893
Civil Engineering (2 vols.)		1893
Know your own Ship	T. Walton	1897
Manual of Laying Off Ships	Watson	1898
Modern Shipbulding and the Men Engaged in it	D. Pollock	1884
Naval Annuals ... ... Lord Brassey		1886, 1887, 1890 to date
Naval Architecture, Manual of (4 copies)	W. H. White	1889
Do. do.	Fincham	1894
Do. Text Book of...	J. J. Welch	1892
Do. Modern System of (3 vols.)... ...	...J. Scott Russell	
Naval Science (4 vols)		
Resistance and Propulsion of Ships	Durand	1898
Resistance of Ships and Screw Propulsion	D. W. Taylor	1893
Screw Propellors and Marine Propulsion...	Chase	1895
Shipbuilding (2 vols.)	Thearl	1886
Shipbuilding, Theoretical and Practical	Prof. Rankine	1866
Stability of Ships	Sir E. J. Reed	1885
Steam Machinery and Steam Naval Architecture (2 vols.) ...	Tredgold	
Steam Navigation	B. Woodcroft	1848
Théorie du Navire (4 vols)...		
Yacht and Boat Sailing	D. Kemp	1891
Yacht Architecture (2 vols.)	D. Kemp	1891

(*c*) *Electrical.*

Alternate Current Transformer in Theory and Practice (2 vols.)	Fleming	1895
Armature Winding	Parshall and Hobart	1895
Dynamo, The	Hawkins & Wallis	1896
Dynamos, Alternators, and Transformers...	Kapp	1893
Dynamo Electric Machinery (2 copies)	Thompson	1892
Dynamo Electric Machines...	Hering	1890
Dynometers and the Measurement of Power (2 copies)... ...	Hather	1892-3
Elementary Treatise on Electricity	J. C. Maxwell	1881
Electric Light	...J. W. Urquhart	1880
Electric Light Fitting	...J. W. Urquhart	1890
Electric Motive Power	Snell	1894
Electric Railways and Tramways	P. Dawson	
Electric Transmission of Energy (3 copies)	G. Kapp	1890
Electric Wiring	...W. P. Maycock	1899
Electrical Engineering (2 copies)	Slingo and Brooker	1898
Electricity and Magnetism (2 vols.)	J. C. Maxwell	1881
Do. do. First book of...	... W. P. Maycock	1891
Electro Magnet	Thompson	1891
Engineer's and Contractor's Book of Prices	Spon	1892-3
Experimental Researches in Electricity (3 vols.)	M. Faraday	1839
Motive Power and Gearing for Electric Machinery	Carter	1896
Motor Vehicles and Motors...	W. W. Beaumont	1900
Practical Electrical Engineering (4 vols.)	... C. H. W. Biggs	1893
Practical Electrical Measurement	... J. Swinbourne	1888
Practical Electricity	Ayrton	1889

Polyphase Electric Currents (2 copies)	S. P. Thompson	1895 and 1897
Short Lectures to Electrical Artizans	J. A. Fleming	1890
Telephone Handbook	J. Pool	1891
Transmission of Power by Electricity		1895

(*d*) *Miscellaneous, etc.*

Acetylene	V. B. Lewes	1900
Aluminium	Richards	1893
Atlantic Ferry	A. J. Maginnis	1900
Chemical Analysis of Iron (2 copies)	Blair	1891 & 1898
Chemistry	Bloxham	1890
Collieries and Colliers	J. C. Fowler	1869
Dechane's Natural Philosophy		1891
Duties of Executors...	F. W. Dendy	1889
Elements of Projective Geometry	Cremona	1885
Geology of England and Wales	H. B. Woodward	1887
*Handy Royal Atlas		1894
Imperial Journal (3 vols.)		
Industrial Resources of the Tyne, Wear, and Tees		1864
Iron Founder, The	S. Bolland	1893
Kinematics or Mechanical Movements	C. W. MacCord	1896
Light	L. Wright	1892
Lit. and Phil. Lectures		1898
Management of an English Railway	G. Findlay	1891
Marine Transport of Petroleum	Little	1890
Materials of Construction	J. B. Johnson	1900
Miscellaneous Scientific Papers	Prof. Rankine	1881
Motion of Fixed Stars	Crayson	1874
Practical Treatise on Petroleum	B. J. Crew	1887
Record of the International Exhibition of London		1862
River Tyne, History and Resources of	J. Guthrie	1880
Service Chemistry	V. B. Lewes	1889
Spectator	A. Morley	
Ventilation and Heating	B. F. Sturtevant	
Water Ways and Water Transport	Jeans	1890
Waterworks Engineering	Sudsbery & Brightmore	1897
*Year Book of Scientific Societies	1890 to date	

(*e*) *Biographical.*

Lives of Brindley and others	Smiles	1874
„ Boulton and Watt	„	1878
„ William Denny	A. B. Bruce	1889
„ Metcalf and Telford	Smiles	1874
„ James Nasmyth	„	1885
„ Smeaton and Rennie	„	1874
„ G. and R. Stephenson	„	1879
„ R. Trevethick	F. Trevethick	1872
Diaries of Sir Daniel Gooch, Bart.		1892

(*f*) *Dictionaries.*

*Dictionary of Engineering (4 vols.)	Spon	1874
*Dictionary of Terms relating to Iron	A. Tolhausen	1870
*French and English Dictionary (2 vols.)	L. Smith & H. Hamilton	1882
*German and English Dictionary	...Theime-Preusser, E. Wesseley	
*Italian and English Dictionary (2 vols.)	Millhouse	
*Spanish and English Dictionary (2 vols.)	Bustamantes	1890
*Technological Dictionary (3 vols.)	A. Tolhausen	1883

(*g*) *Registers.*

**Lloyd's Register of British and Foreign Shipping*, London.

**Bureau Veritas International Register of Shipping*, Paris.

**Germanischer Lloyd Internationales Register*, Berlin.

**The British Corporation for the Survey and Register of Shipping.*

NORTH-EAST COAST INSTITUTION

OF

ENGINEERS AND SHIPBUILDERS.

SEVENTEENTH SESSION, 1900-1901.

PROCEEDINGS.

The Seventeenth Session of the Institution was opened on Saturday, October 27th, 1900.

In recognition of the kind and hospitable way in which the members had been received by the various Hartlepool and West Hartlepool firms on the occasion of the Institution's visit to these ports, the members were invited by the following firms on the river Tyne to visit their works on the afternoon of Saturday, October 27th, 1900, viz. :— The works of Messrs. The Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne, and the shipbuilding yard of Messrs. C. S Swan and Hunter, Wallsend-on-Tyne.

VISIT TO THE WORKS OF THE WALLSEND SLIPWAY AND ENGINEERING CO., WALLSEND.

OCTOBER 27TH, 1900.

By the kind invitation of the management, the members visited the establishment of the Wallsend Slipway and Engineering Co, Ltd., at Wallsend.

The steamer "J. C. Stevenson" having been placed at the disposal of the members by The Tyne Improvement Commissioners, they embarked at the Newcastle Station of the Tyne General Ferry Co., and were brought down to Wallsend by this means. On their arrival at the slipway they were conducted round the establishment by Mr. W. Boyd, Managing Director and first President of the Institution ; Mr. Andrew Laing, General Manager ; Mr. R. Wallis, Works Manager ; Mr. J. W.

Tocher, Manager of the Ship Repairing Department; and Mr. M. Murray, Secretary.

The Company was formed, in 1873, as a ship repairing establishment by the late Mr. Charles Mitchell, and a large volume of repairing work is still turned out year after year, both by means of the two slipways, and the large and fully equipped graving dock. The Company has, perhaps, been more prominently brought before the public by reason of its success in the marine engineering department; more especially has this been so during the last few years, when the Company has come very much to the fore as builders of machinery of the largest size, and, in many cases, of a very special character.

The works were greatly extended and improved some three or four years ago—large additions were made to the machinery, and many advantageous re-arrangements were effected. One feature of these changes was the new addition of a very fine erecting shop, which is worked with two powerful electric travelling cranes, and sundry hydraulic cranes for lighter work.

The establishment is a particularly interesting one, comprising, as it does, the building of marine engines and boilers, and a repairing branch for all kinds of ship repair work, including lengthening, which latter work has been recently exemplified in the case of the s.s. "Savoia," of Genoa, which was lengthened by 66 feet, and also bossed out at the stern.

The members had an opportunity of seeing and examining the method of docking a war vessel, as the Norwegian gunboat "Norge" had been drydocked the day before.

The frontage at the disposal of the Company extends to nearly 2,000 feet, which includes 1,000 feet in a stream at the eastern side of the yard, which has been dredged and jettied to accommodate the largest and deepest vessels.

All the various shops, from the new erecting shop at the top of the yard to the boiler shop at the bottom, seemed to be very full of work, especially was this the case in the machine shop, where also were seen some of the latest improvements in labour saving appliances, notably, perhaps, a very large horizontal boring machine, which, we believe, is capable of dealing with the largest cylinders.

Not the least interesting part of the establishment was the board room, with its walls decorated by photographs, showing the improvements which have been made in marine engines since the Company was formed in 1873.

SHIPBUILDING YARDS OF MESSRS. C. S SWAN & HUNTER, LTD.

These works were originally started in 1872 and then consisted of what is now known as the Company's West Yard, covering an area of about 7 acres. From time to time the works were extended, till at the present time the total area has increased to about 35 acres. As the works increased in size, machinery was laid down to cope with the building of the largest class of merchant vessels, and a separate yard has been equipped with special machinery for building floating docks. Four of the shipbuilding berths are of practically unlimited length. From three of these, vessels can be safely launched over 700 feet long, and from the fourth up to any length.

One of the most notable features of these works is the covered building berths in the Company's East Yard. These sheds are each 500 feet long (which length can very simply be increased at any time) and the larger one is 71 feet 6 inches wide in the clear, the smaller one being 68 feet in the clear. The whole of the roofs and for some distance down each side are covered with glass, so that work can be carried on in any weather. Under the roof of each shed are two travelling and revolving electric cranes carried on girders running the whole length of the shed. Each of these cranes will lift 3 tons and travel at the rate of 300 feet per minute. On the roof of the eastern shed is a cantilever travelling crane with a 65-feet jib extending over the easternmost berth. This crane will also lift 3 tons.

A large number of machines in various parts of the yards are driven by electric power, the current being generated in a power house situated in a central position. The works are also exceptionally well lighted by arc and incandescent lamps. There are six large dynamos driven by two of Robey's compound engines, steam being generated in Babcock & Wilcox water tube boilers. Above the boilers is placed an atmospheric condenser to ensure a supply of pure water to the boilers and to increase the efficiency of the plant.

In the West Yard there are three berths arranged for vessels up to 430 feet in length with suitable machinery, whilst the pontoon dock yard is reserved for building floating docks, dock gates and work of a similar nature. In this yard there is a machine of peculiar interest, viz., a multiple automatic punch. This machine will punch a plate 6 feet 6 inches wide, 26 feet long and $\frac{7}{8}$ inch thick. Such a plate can be punched in about 6 minutes, the pitch of the holes being mathematically correct.

At the time of the visit the following vessels were under construction on the berths or finishing at the jetty:—

A steamer 470 feet B.P. × 56 feet 3 inches × 34 feet 10 inches for Messrs. Thomas and James Harrison, Liverpool.

2 twin screw steamers 470 feet B.P. × 56 feet × 34 feet 10 inches for Messrs. Elder, Dempster & Co., Liverpool.

3 steamers 350 feet × 46 feet × 30 feet 1 inch for Messrs. C. T. Bowring & Co., Liverpool.

2 steamers 348 feet × 45 feet 3 inches × 28 feet 9 inches for Messrs Hudig & Veder, Rotterdam.

A floating dock for Bermuda 545 feet × 126 feet, to lift a vessel of 16,500 tons, drawing 33 feet of water; and a smaller floating dock for a Russian railway company.

By invitation of the Tyneside Past-Presidents (Mr. William Boyd, Mr. Wigham Richardson, Col. Henry Swan, and Sir B. C. Browne) tea was provided for the members on their return to Newcastle-upon-Tyne.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SEVENTEENTH SESSION, 1900-1901.

PROCEEDINGS.

SEVENTEENTH ANNUAL MEETING OF THE INSTITUTION, HELD IN THE LECTURE THEATRE OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON SATURDAY EVENING, OCTOBER 27TH, 1900.

HENRY WITHY, ESQ., J.P., IN THE CHAIR.

The SECRETARY read the minutes of the Closing Business Meeting of last (sixteenth) session held in Newcastle-upon-Tyne on May 18th, 1900, which were approved by the members present and signed by the President.

The ballot for new members having been taken, the President appointed Mr. J. R. Fothergill and Mr. G. E. Macarthy to examine the voting papers and the following gentlemen were declared elected :—

MEMBERS.

Haswell, Wm. Spence, Engineer, c/o Messrs. Tangye, Ltd., 3, St. Nicholas Buildings, Newcastle-upon-Tyne.

Irvin, Matthew B., Sup. Engineer, c/o Messrs. The Nile Navigation Co., Sharia Kamel, Pasha, Cairo, Egypt.

Skentelbery, Charles, Engineer, Linden Villa, Gosforth, Newcastle-upon-Tyne.

Stevenson, Robert, Engineer, Bentham Buildings, Newcastle-upon-Tyne.

Watson, Michael, Consulting Engineer, 4, St. Nicholas' Buildings, Newcastle-upon-Tyne.

Williamson, Robt. Tate, Engineer, 119, Bede Burn Road, Jarrow-on-Tyne.

ASSOCIATES.

Brown, Charles Ernest, Accountant, 1, Ashleigh Villas, East Boldon, near Sunderland.

Lucock, George, Merchant, Dean House, Tyne Dock.

Wilkie, John William, Shipowner, Prince's Buildings, Quayside, Newcastle-upon-Tyne.

GRADUATES.

Gray, Robert Bertram, Engineer Apprentice, Burnside Villa W., Newcastle-upon-Tyne.

MacBride, James Douglas, Ship Draughtsman, 76, Hillside Avenue, Arlington Heights, Mass., U.S.A.

Mudd, Percival Arthur, Engineer Draughtsman, Greencliffe, Hartlepool.

Nichols, George Henry, Engineer Apprentice, 30, Denmark Street, Gateshead-on-Tyne.

Spittle, Henry Stuart, Engineer Apprentice, 20. Eskdale Terrace, Newcastle-upon-Tyne.

Taylor, John Thomas Lloyd, Engineer Draughtsman, 8, Ravensworth Terrace, Bensham, Gateshead-on-Tyne.

Tsimenis, Andrew, Naval Architect, Durham College of Science, Barras Bridge, Newcastle-upon-Tyne.

VOTES OF THANKS.

The PRESIDENT said, before proceeding with the regular business, it was their duty to acknowledge the kind way in which they had that day been entertained by their friends on Tyneside. Two very notable firms had kindly opened their works for their inspection, and the two chief classes of their members, engineers and shipbuilders, had each had the opportunity of seeing what their neighbours were doing. As there was not time to visit both places, he had joined the party who visited the Wallsend Slipway and Engineering Works, and he had great pleasure in bearing testimony to the courteous way in which they had been received by Mr. Boyd and his officials, and the care taken by them to make the visit both interesting and instructive He had no doubt those who had visited the shipbuilding yard of Messrs. C. S Swan and Hunter had met with a similar reception He desired to move that the Secretary be instructed to write both of these firms, conveying to them their hearty thanks for the cordial reception they had given them. The Tyne Improvement Commissioners had kindly placed their steamer, "J. C. Stevenson," at their disposal, to convey them down and up the river, he would also move that the Secretary be instructed to write that Corporation, thanking them for their kindness. On their return to Newcastle they found that not only had they been entertained intellectually, but preparations had also been made for their bodily comforts. He desired, therefore, that the Secretary be instructed to convey to the Tyneside Past-Presidents (Mr. W. Boyd, Mr. Wigham Richardson, Col H. Swan, and Sir B. C. Browne) their thanks for the tea kindly provided by these gentlemen.

Mr. J. R. FOTHERGILL (Vice-President) said it gave him great pleasure to second the votes of thanks, so ably proposed by the President, to the various firms and gentlemen who had so well administered that afternoon to their enjoyment and pleasure. He felt sure the resolutions would have the hearty concurrence of all present. These social gatherings were conducive to the best interest of the Institution, in that they brought members into closer touch, so that they knew one another better, and thus took greater interest in the well-being of the Institution. It was a pleasing feature of these gatherings to note the number of young men present; it gave them the opportunity of seeing the different methods employed in different works, and particularly did it facilitate their becoming known to their seniors, to the mutual advantage of both. He felt sure, after the successful gathering that afternoon, and the great interest shown by all in what they saw, their hosts would not regret having thrown their works open. He had great pleasure in seconding the resolutions.

The resolutions were carried unanimously.

MR. BOYD'S REPLY.

Mr. W. BOYD (Past-President) begged to thank them for the vote of thanks which had just been passed. They had been very pleased to see so many members of the Institution at the Slipway that afternoon, and were glad that members had been interested by what they had seen. He regretted that Mr. Hunter was not present to speak for the firm of Messrs. C. S. Swan and Hunter, but felt sure he might thank them on Mr. Hunter's behalf for the vote of thanks they had passed. He also begged to thank them, on behalf of the other Past-Presidents and himself, for the second vote of thanks which had been passed in return for the slight hospitality which they had been able to offer them. It had been felt by some of the Tyneside members that as the Institution had on former occasions received several opportunities of inspecting works at Hartlepool and elsewhere, and had received much kindly attention on the occasion of those visits, that the present was a good opportunity of making some slight return, and he was very glad they had enjoyed themselves. In conclusion, he could not help expressing the hope that the large attendance that evening would

be continued throughout the session, and that their new President might be supported by good meetings even on those occasions when there were no supplementary attractions similar to those which had been in existence that afternoon.

The SECRETARY read the Council's Report, and submitted the Financial Statement for last (sixteenth) session.

The PRESIDENT delivered his Inaugural Address.

Mr. C. H. INNES read a paper on "The Stress Produced in a Connecting Rod by its Motion."

COUNCIL REPORT.

(SIXTEENTH SESSION, 1899–1900.)

The Council has pleasure in stating that the financial position of the Institution is still satisfactory, but regrets having to record that the subscriptions in arrears amount to £75 1s. 6d.

A further sum of £300 has been invested on mortgage of the Tyne Consolidated Fund at 3¼ per cent. for a period of fifteen years.

The sixteenth session was opened on the 20th day of October with a conversazione and ball, at the kind invitation of the President (Sir B. C. Browne) and Lady Browne, and was attended by a large assemblage of ladies and gentlemen.

During the year the following papers were read and discussed :—

"The Working Stress of Materials used in British Locomotive Construction." By Mr. F. W. Jennings.

"Screw Fans." By Mr. C. H. Innes, M.A.

"Receiver Drop in Multiple Expansion Engines." By Professor R. L. Weighton, M.A.

"The Distribution of Materials in the Upper Works in Large Steamers." By Mr. S. J. P. Thearle.

"Some Considerations affecting the Training of Young Engineers." By Mr. W. C. Borrowman, Wh.Sch.

"The Fouling of Ships." By Mr. W. H. Atherton, M.Sc.

"The British Naval Engineer: his present position and influence on our Sea Power." By Mr. D. B. Morison.

The latter paper drew forth an interesting discussion, and at the closing meeting of the session the following resolutions were agreed to by the members :—

1.—That in view of the national importance of an investigation and discussion by Engineers of the subject matter of Mr. D. B. Morison's Paper, the Secretary be instructed to communicate with the various Marine Engineering Institutions throughout the Kingdom, enclosing a copy of the paper and discussion, and suggest that each should hold a Meeting for the discussion of the subject; that all discussions should be incorporated in one volume, such volume to form part of the transactions of each Institution.

2.—That a small Committee be formed by each Institution, the whole to be embodied in one General Committee, which will draw up a report for submission to the Government as representing the opinions and recommendations of the Marine Engineers of the United Kingdom with reference to the Engineering personnel in H.M. Navy.

3. That the following gentlemen be elected to form the Committee t represent this Institution :- Sir B. C. Browne, Sir Thomas Richardson Mr. D. B. Morison, Mr. H. Withy, Mr T. Westgarth, and Prof. R. I Weighton.

The engineering gold medal for the fifteenth session was awarded t Mr. Tom Westgarth for his paper on "Works Organisation."

On the occasion of the Institution's visit to West Hartlepool o February 24th, 1900, the members visited the shipbuilding yard o Messrs. Furness, Withy & Co. The visitors were cordially received an most hospitably entertained by the firm.

Owing to the state of matters in South Africa, it was thought un advisable to hold the annual Institution dinner.

It is proposed to hold an International Engineering Congress i Glasgow during the year 1901. This Institution having been requeste by the Institution of Civil Engineers to send two representatives to si on the London Committee, the following gentlemen were appointed b the Council :--Sir W. T. Doxford, M.P., and Sir Thomas Richardson.

The lease of the Rooms occupied by the Institution having expired the Council has thought fit to renew the same for a further period o five years.

During the eleventh session of the Graduate section eight meeting were held and were well attended.

At the opening meeting the Chairman (Mr. R. Hinchliffe), gave a address on "Modern Ship and Engine Building Plant," and during th session the following papers were read and discussed :—

"Worm Gearing." By Mr. R. G. Nichol.
"Ship Resistances." By Mr. J. S. Posgate.
"The Parsons Steam Turbine Engine." By Messrs. W. J. A. London an A. Q. Carnegie.
"Stability." By Mr. R. S. Varty.
"The Balancing of Engines." By Mr. R. C. Browne, jun.
"Backward Electric Motors for Traction." By Mr. Talbot Duckitt.
"Discussion on Metallic Packing." Opened by Mr F. W. G. Scook.

The following places of interest were visited, and the thanks of th Institution are due to the principals and officials of these establishments for the kindness and courtesy extended to the junior members :—

Messrs. The N. E. Marine Engineering Co., Sunderland.
Messrs. The North Eastern Steel Shipbuilding Co., Hawthorn-on-Tyne.
Messrs. George Clark & Co., St. Andrew's Engine Works, Newcastle upon Tyne.

The following awards were presented to the authors of papers read before this section during the tenth session :—

Books, &c., to the value of £4 to Mr. F. W. G. Snook for his paper on "Lubrication."

Books, &c., to the value of £3 11s. to Mr. Talbot Duckitt for his paper on "The Design and Equipment of Electrical Power Plant for Collieries."

Mr. H. B. Donaldson has been elected Chairman of this section for the current year, and Mr. W. H. Waddingham has been re-elected Hon. Secretary.

During the year the following additions have been made to the list of members :—Life Member, 1 ; Members, 57 ; Graduates raised to Members, 18 ; Associates, 19 ; Graduates, 32.

The Council regrets having to record the loss by death of the following :—Members, Mr. J. G. Joicey, Mr. F. Moore, Mr. J. Y. Short, Mr. W. Stafford, Mr. J. G. Sowter. Graduate, Mr. George Mace.

The Institution has also lost by resignations and other causes : - Members, 50 ; Associates, 11 ; Graduates, 16.

The total number of names now enrolled is as follows :—

Honorary Members	4
Life Members	8
Members	812
Life Associates	3
Associates	130
Graduates	115
Total	1072

Messrs. Walker & Hall and Messrs. Thos. Firth & Sons having graciously invited the members of the Institution to visit their several works in Sheffield, the invitation was accepted by the Council. The members arrived at Sheffield about noon on Wednesday, August 29th, 1900, and the afternoon was spent in inspecting the electro works of Messrs. Walker & Hall. By the invitation of this firm the visitors were entertained at dinner in the evening, the chair being taken by Colonel Bingham and the vice-chair by Major Bingham. On the following morning Messrs. Thos. Firth & Sons' steel works were visited, after which the members drove to Baslow, over Froggatt Edge, where lunch was served. The party left Sheffield in the evening for home. During the stay the works of Messrs. Seebohm & Diechstahl were also thrown open for inspection.

NORTH-EAST COAST INSTITUTION OF

STATEMENT OF RECEIPTS AND PAYMENTS

Receipts.

To Balance from last Account—									£	s.	d.	£ s. d.
At Bank												337 8 4
„ Subscriptions received for Session 1899-1900—												
246 Members at £2 2s.								£516	12	0		
515 Members „ £1 1s.								540	15	0		
128 Associates „ £1 1s.								134	8	0		
109 Graduates „ 10s. 6d.								57	4	6		
998											1,248	19 6
„ Association of Foremen Engineers and Draughtsmen—												
One year's Subscription											20	0 0
„ Life Member—Hugo MacColl, Esq.											21	0 0
„ Subscriptions received in advance											2	2 0
„ Arrears from Sessions 1898-99—												
8 Members at £2 2s.								£16	16	0		
10 Members „ £1 1s.								10	10	0		
2 Associates at £1 1s.								2	2	0		
2 Graduates „ 10s. 6d.								1	1	0		
											30	9 0
												1,322 10 6
„ Transactions sold this Session											10	10 10
„ Copies of Members' Papers supplied											18	2 0
												28 12 10
„ Tyne Improvement Commissioners—												
One Year's Interest to 21st June, 1900, on £605, at 3½ per cent.											21	18 6
Viz.:—Medal Fund £274 0 0												
Graduates' Award and Life Members' Fund 331 0 0												
Less—Tax											0	16 0
												21 2 6
One Year's Interest to 10th July, 1900, on £500, at 3½ per cent.											18	15 0
Less—Tax											0	13 4
												18 1 8
One year's Interest to 4th May, 1900, on £300, at 3 per cent.											9	0 0
Less—Tax											0	6 2
												8 13 10
One year's Interest to 13th July, 1900, on £300, at 3½ per cent.											9	15 0
Less—Tax											0	7 4
												9 7 8
Half-Year's Interest to 9th June, 1900, on £300, at 3½ per cent											4	17 6
Less Tax											0	4 0
												4 13 6
												£1,750 10 10

ENGINEERS AND SHIPBUILDERS.

FOR SESSION ENDING 31ST JULY, 1900.

Payments.

	£	s.	d.	£	s.	d.
By Transactions and Papers—						
Lithographing	90	0	0			
Printing and Binding	227	5	3			
				317	5	3
„ Stationery and Circulars	76	7	3			
„ Reporting	26	10	0			
„ Rents—						
Offices and Electric Light Fittings	112	12	9			
Lecture Rooms	7	4	0			
Telephone	8	0	0			
				230	14	0
„ Rates, Gas, Electric Light, and Insurance...				27	3	11
„ Salaries—						
Secretary. Salary	340	0	0			
„ Commission	65	2	6			
Assistants'	36	8	0			
„ Postages, Stamps, Post Cards, Parcels, etc.	124	7	3			
„ Secretary's Expenses and Allowances to Hall Keepers, etc.	27	14	0			
.. Office Expenses, Coals, Cleaning. etc.	30	1	9			
„ Measured Mile Posts—Rent...	6	6	0			
„ Auditor's Fee	5	5	0			
„ Lantern Expenses	2	5	0			
				637	9	6
„ Library Account—						
New Books	11	16	2			
Bookbinding	6	7	6			
				18	3	8
„ Gold Medals' Fund—						
Gold Medal awarded				5	10	0
„ Graduates' Award Fund—						
Amounts awarded for Papers				7	11	0
„ Tyne Improvement Commissioners—						
Investment at 3½ per cent. per annum				300	0	0
„ Balance at Bank				206	13	6
				£1,756	10	10

The Balance Sheet for Session ending 31st July, 1900.

Liabilities.

Gold Medals' Fund—				£	s.	d.
Amount at 31st July, 1899 ...	£291	4	0			
Interest on Investment ...	9	11	6			
				300	15	6
Less—Medal awarded				5	10	0
						295 5 6
Graduates' Award Fund—						
Amount at 31st July, 1899 ...	£223	6	5			
Interest on Investment ...	7	10	8			
				230	17	1
Less—Awards for Papers				7	11	0
						223 6 1
Payments by Life Members and Associates—						
Amount at 31st July, 1899				210	0	0
Add—Life Member this Session ...				21	0	0
						231 0 0
Subscriptions paid in advance						3 3 0
General Capital						2,177 3 2
						£2,929 17 9

Audited and certified,
R. W. SISSON, F.C.A.

Newcastle-upon-Tyne,
12th October, 1900.

Assets.

Subscriptions in Arrear—				£	s.	d.
Session 1898-99				5	5	0
„ 1899-1900				69	16	6
						75 1 6
Stock of Transactions, valued at						195 6 9
Office and Library Furniture, Safe, etc., as at 31st July, 1899				135	5	4
Less—Depreciation				13	10	6
						121 14 10
Books in Library—						
As at 31st July, 1899 ...	£315	16	10			
Less—Depreciation ...	31	11	10			
				284	5	0
Additions this Session—						
Books received in exchange for Transactions				30	0	0
Purchases				11	16	2
						326 1 2
Tyne Improvement Commissioners—Investment in respect of the following Accounts, viz.:—						
Gold Medals' Fund				274	0	0
Graduates' Award Fund				215	15	0
Payments by Life Members and Associates				115	5	0
General Capital—						
As at 31st July, 1899 ...	£1,100	0	0			
Add—Investment at 3½ per cent.	300	0	0			
				1,400	0	0
						2,005 0 0
Cash—At Bank						206 13 6
						£2,929 17 9

The PRESIDENT moved that the Report be entered upon the minutes in the ordinary way. He thought it was an exceedingly satisfactory one.

Sir B. C. BROWNE (Past-President) seconded the proposition, and said he noticed the Institution was growing stronger and stronger every year. He thought the more they knew of each other, and the more they sub divided each other's work, the Institution was sure to prosper.

The Council Report and Financial Statement were adopted.

The PRESIDENT then delivered his Inaugural Address.

PRESIDENT'S ADDRESS.

By HENRY WITHY, Esq., J.P.

(Delivered before the Institution in Newcastle-upon-Tyne, October 27th, 1900.)

First, may I be allowed to thank the members of this Institution for the great honour they have conferred on me by asking me to be their President for a term, and while I fear that I shall not be able to fill the office in a manner worthy of the example of my distinguished predecessors, the Institution may rely upon my best efforts being put forward to keep up the reputation that has been gradually built up since its formation; and with the same kind support so generously and unanimously accorded to Presidents in the past by the Council and members, I hope the Institution will retain its full place as third of its kind in connection with the professions and trades we are all so familiar with.

At the close of the first session in May, 1885, the total number of members, associates and graduates, was 452, while at the present time we have 1,072 on the books, and the total amount of money invested, including Gold Medal and Graduates' award funds, is £2,005. This I consider to be very good progress, and I trust during my term of office that we shall have still further additions to our ranks.

Medals have been granted for the best papers each year since 1889.

The Graduate Section of this Institution has been in existence for ten years, and the papers read are increasing in interest every year. This section is of great value to young men if they will only take full advantage of it.

I would strongly bring before apprentices, graduates, etc., of the present day, the necessity for acquiring a thorough practical knowledge of all details of their trade, whether it be shipbuilding, engineering, or one of the attendant trades; but at the same time the theory must not be neglected. It may be remarked in passing that the highly-trained mathematician is not the best paid man in the works; a knowledge of details and the power of organisation commanding the highest remuneration.

In addressing such a society as this I need make no apology for confining my remarks largely to shipbuilding and its allied trades.

Great strides have been made during the last few years in shipbuilding and engineering, as instanced by the large number of vessels now afloat carrying from 12,000 to 20,000 tons. There is no doubt that the increased depth of water at our large ports has greatly reduced the difficulties of shipbuilders in designing vessels of large deadweight. One of the notable points in connection with shipbuilding is the extensive use of cold-flanging, which has been proved to be superior to the old method of fitting angle-bars, and which has been long recognised by engineers and boilermakers.

As illustrating the advances made, I find :—

1819	Phœnix, paddle, crossed the Atlantic in 29 days 11 hours.					
1850	Atlantic	do.	12	knots,	2,860 tons.
1862	Scotia	do.	13	knots,	3,870 tons.
1871	Adriatic	do.	15	knots,	3,888 tons.
1880	City of Rome	do.	17	knots,	8,144 tons.
1890	New York and Paris ...	do.	20	knots,	
1893	Campania	do.	22	knots,	19,000 tons.
1897	Kaiser Wilhelm der Grosse	do.	22·62	knots,	20,000 tons.
1900	Deutschland	do.	23	knots,	23,000 tons.

and crossed the Atlantic in 5 days 11 hours, as compared with 29 days 11 hours in 1819.

One feature in the shipbuilding trade has been the construction, recently, of several very large pontoons or floating docks, such as that for Havannah, and the one now building for the Spanish Government. I believe others are under construction at the present time.

In the very large steamers that have been built during the last year or two, it has been found necessary to use hydraulic machines for riveting the sheer strake and topside plating—it having been demonstrated that it was quite impracticable to set up these long rivets through such thick plating by hand.

In many shipyards pneumatic tools have been introduced, more especially for caulking, chipping and drilling, similar to those in use in boiler shops. Pneumatic rivetting has been in use largely in American shipyards where lake steamers are built, and the same has been tried in this country, but I have not yet seen any such appliance capable of dealing with the larger rivets required in our ordinary practice. No doubt there is a great field open for the substitution of machine rivetting to take the place of hand labour, which is becoming more and more laborious as the vessels increase in size.

Remarkable progress has been made in the shipbuilding industry by Continental firms during the last few years ; and with such vessels as the "Deutschland" and "Kaiser Wilhelm der Grosse" to their credit, we

must exert all our energies if we are to retain our position as the first shipbuilding nation in the world. One pleasing fact, however, is the large number and the large size of steamers built to the order of foreigners in this country, shewing that the Continental supply does not yet appear to be nearly equal to the demand.

Mr. Wigham Richardson's contention of 1890 that the load line should be a condition of the classification has been fulfilled, but I do not think we should relax our efforts until the freeboard tables are made universal, or, failing that, be applied to foreign vessels loading in English ports.

There is at present a growing tendency to fit twin screws in large passenger steamers. The fact of having two engines gives a more complete sense of security against total disablement. Twin screws have also been fitted in cargo steamers of moderate power, but I am disposed to think that unless the I.H.P. exceeds say 8,000 it is hardly worth while fitting twin screws in cargo vessels. I believe it is generally accepted that the risk is less with twin screws, but so far as I have been able to ascertain, underwriters have not taken this view and do not offer any inducement for twin screw ships.

There has been no signal advance in marine engineering during the last few years, such, for example, as marked the introduction of the triple expansion engine; but progress has been well sustained, and although the standard steam pressure is still from 180 to 200 lbs., yet tank boilers have been built for 265 lbs. working pressure, and are reported to be giving very satisfactory results. Water tube boilers are not making such headway in the mercantile marine, the general opinion being that notwithstanding the fact that greater theoretical economy results from still higher steam pressure yet the commercial economy is largely dependent on the type of steam generator adopted.

The three crank triple expansion engine is still the popular type for moderate powers, the Schlick & Tweedy balanced quadruple engine on four cranks has, however, been adopted in many passenger boats in which minimum vibration is a great desideratum. This system has already been applied to about 100 battleships, passenger liners, etc., with most satisfactory results. The five crank quadruple expansion engine introduced by the late Mr. Mudd has been very successful in not a few cases. I notice that with quadruple expansion engines the highest efficiency claimed by the builders is ·98 lbs. of coal per I.H.P. per hour. This result was obtained by the use of Ellis & Eaves induced draught, boilers working at 260 lbs. pressure and highly superheated steam. Many

engineers are sceptical as to whether equal results with the same steam pressure could not be obtained with four or even three cranks.

The tendency undoubtedly is in the direction of simplicity of detail, and whether it be in boilers, engines or auxiliaries, there is a willingness to sacrifice some of the highest possible economy, if it involves complicated mechanism which requires skilled attention above the obtainable average, or increases the chances of breakdowns or other troubles at sea.

The Tyne I believe can now claim to have built the fastest vessel afloat, the "Turbinia." This vessel is fitted with Parsons' marine steam turbines. Similar machinery has been fitted on H.M. "Viper," a vessel 210 feet long, and a speed of 37·113 knots per hour has been obtained on a consumption below the average for destroyers with ordinary engines. Whether this type can be adapted to ocean going steamers has yet to be demonstrated, but their success for small vessels is undoubted.

In 1890 Mr. Wigham Richardson referred to the roundabout and wasteful system of generating electricity from coal. At present, however, although the system has only been improved we have very little to complain about. A plant of multitibular boilers with triple expansion engines coupled direct or connected by belts to dynamos leaves very little to be desired, either in the way of economy or upkeep.

At Middleton shipyard a plant of this description has been running for over five years, and during 1896-97 the cost of power production, attendance and repairs was 6·4d per £ of wages paid.

Taking another view of the matter, the cost of power production works out at ·9 of a penny per Board of Trade unit.

Since the introduction of electric driving we have doubled our wages bill, and doubled the number of machines, yet the cost of superintendance has not relatively been increased, and we consider that electric driving has been a large factor in our greatly increased output.

Middleton shipyard was the first in the world to be wholly worked by electricity.

Great strides are being made in America with large electric cranes for dealing with coal, ores, etc., and before very long an electric crane will be at work in a shipyard on the Tyne with a fore and aft travel of 950 ft. and an outreach from the centre on each side of about 100 feet and a lift of 80 feet.

Great improvements have been made in the manufacture and design of machine tools during the last few years, and for them there has been a great demand. There are at present a very large number of American

lathes and other tools in this country, and some of these have been brought to a very high state of efficiency, but I believe it is possible to get machines of equal or better design and quality made in this country. Our own manufacturers have not specialized so much as Americans, and I think they would do well to follow our cousins in this direction.

Engineers generally find it more economical to throw out an old tool and substitute an up-to-date machine which will do the work in less time and make a better job.

In 1890 Lloyd's Committee invited certain members of the learned societies to appoint representatives to assist their sub-committee for Surveyors, now commonly called the Technical Committee, and I believe the members of Lloyd's Committee will agree that the advice and assistance tendered by these experts has materially helped them in their endeavour to perfect their rules and bring them up to date.

The great number of accidents to propeller shafts has recently brought this matter very prominently before the engineering mind. The recent additions made by Lloyds should do a great deal towards reducing the number of casualties. A great number of accidents are no doubt the direct result of sending steamers on long voyages in a light condition, when abnormal strains are put upon the shafts.

The Government a few years ago adopted a definite plan of increasing the fleet year by year, but there appears to have been lately a stoppage in the orders given out. In view of recent complications in different parts of the world, I believe the Admiralty would be well advised to purchase transports specially suitable for artillery, and that our immense mercantile marine could at any time deal with their requirements for carrying troops.

The metric system of measurements is now legal in this country, and I should be glad to see it universally used, as I believe it would be more convenient and would enable us to attain a uniform system to take the place of the various and confusing weights and measures in use in different parts of the United Kingdom.

The first description of the Bell telephone appeared in the *English Mechanic* in the early seventies, and from that description I immediately made instruments and got them to work very well. The first telephone I saw in public use was at the Royal Agricultural Show, held at Bristol in the year 1878, and about this time I fitted up a telephone from one side of the shipyard to the other.

The earlier transmitters and receivers were both of the same construction, but now most of the receivers are of the microphone pattern.

I think that muncipalisation of telephone services is a mistake, and that better results are likely to be obtained where there is competition.

Wireless telegraphy appears now to be an accomplished fact, and is being installed on a number of our battleships. I notice that successful experiments have been made between stations 25 miles apart.

The larger steamers of the North German Lloyd have the necessary apparatus on board to enable them to communicate with certain light-ships as they pass.

The important question of drainage of towns has received a great deal of attention, but there is still ample room for improvement. Destructors are being built in various parts of the country, and, with careful management, are in many cases profitable investments, as sufficient heat can be generated by the refuse to light at least a proportion of the streets.

The Shoreditch Destructor disposed of 26,000 tons of refuse in twelve months at a cost of 2s. 6·9d. per ton: this includes labour, supervision, repairs, etc. The clinker residue was 32 per cent., but this is used for making mortar, concrete paving, slabs, etc. From a sanitary point of view this is apparently a perfect method of dealing with refuse.

The ventilation of public and other buildings will, I am afraid, remain a vexed question. Up-cast and down-cast ventilators are all very well in their way, but without means of keeping the air in motion they are of little use. Large numbers of electric fans are now being fitted, and, I believe, with excellent results No great difficulty is experienced in ventilating a moving vessel. In the Canadian cattle trade, fans to cattle spaces are required by the regulations.

The better relations between masters and men are amply demonstrated at the meetings of the Tyne, Wear, Tees and Hartlepools shipbuilders, and at the meetings of the Federated Shipbuilders, which meet deputations of workmen from time to time to discuss wages and other matters of great importance to both parties.

It is perfectly clear to me that the interests of employers and men are identical; in busy times it is quite right that workmen should benefit as well as employers, but if they demand too much they will check the advance in trade. In slack times they should be willing to accept reductions, and I am convinced they would be if they recognized more fully that a concession on their part would do much to help employers to obtain orders.

Various agreements are now in force for the prevention of strikes; Demarcation Boards have sprung up all over the country, by which

friction between various trades is greatly minimised; Agreements between platers and their helpers, etc., are in operation; all of the above show a healthy desire to work amicably together.

As a rule, we have little difficulty in dealing with the Unions which are old enough to have found out for themselves the value of organisation, and the necessity of complying with the arrangements and agreements made by their delegates.

Trouble sometimes arises, however, through delegates appearing at meetings having little or no authority, and being apparently unable to use whatever power may be vested in them.

A very serious matter, especially in connection with shipyards, is the large amount of time lost by the workmen. The large number of cheap excursions almost every week no doubt aggravates this evil, which has assumed startling proportions.

The Engineering Employers' Federation, and the more recently formed Shipbuilders' Federation, are already giving proofs of the great value of organisation.

It gives me great pleasure to acknowledge the good feeling which exists between shipbuilders. Few shipbuilders object to their neighbours seeing new plant or recent improvements, and although competition is at times very keen I have not noticed that it in any way affects this reciprocity.

VOTE OF THANKS.

Mr. W. Boyd moved that a cordial vote of thanks be given to the President for his most interesting address, which, he said, covered such a wide field of subjects that were of immense interest to all present that night. Continuing, the speaker said he thought that the preparing of an address of that kind must become more difficult to the President as years went on. It was true that Mr. Withy had had some notable examples to guide him in the past, but still it was difficult to find new items of interest for such an Institution as theirs. On the present occasion, he felt they might congratulate themselves very warmly on the very interesting address which Mr. Withy had prepared. He felt it embraced so many subjects that there would probably be many present that night who would like to make some remarks upon it. Proceeding, Mr. Boyd referred to the President's statement anent the growing tendency to fit twin screws in large passenger steamers, and said he took exception to Mr. Withy's conclusion that it was hardly

worth while fitting twin screws in cargo vessels, unless the I.H.P. exceeded 8,000. He had had some experience in this direction, and though it might or might not be as the President said, he differed with him. The value of fitting twin screws in vessels of less power was being recognised by the principal shipowners of the present day. They were finding that for vessels with less power than 8,000 it was to their advantage to make sure of increased speed and protection to their property by adopting machinery of the type in question. The President had also referred to the Graduates' Section of the Institution, and the gold medals that had been presented. It might be interesting to remind the meeting that the institution of the medal was due to Mr. Withy's own firm. The medals had been got from a fund which the gentlemen belonging to their President's firm had given to the Institution.

Mr. WIGHAM RICHARDSON (Past-President) seconded the vote of thanks. He thought the address was an extensive, thoughtful, and suggestive one. As subjects for their Institution were difficult to get, he thought that their Secretary might find, in two or three passages therein, various subjects for admirable papers and interesting discussions. With respect to the metric system of measurements alluded to by the President, he (the speaker), after eulogising Mr. Baines' paper on the subject, with which, however, he had not been able to agree, asked if after all it was necessary for this Institution to invoke the assistance of Parliament?

If the metric was a good system and if it was advisable for engineers to adopt a new system for weighing and measuring, there was no need for them to appeal to Government at all. If they wished it, there would be no difficulty in carrying it out for themselves and in their own works. These were, however, great *ifs*! The subject appeared to him to be one that might come under discussion in that Institution. He had pleasure in seconding the vote of thanks, and saying how much they welcomed Mr. Withy on the banks of the Tyne.

Sir B. C. BROWNE also asked to be allowed to say a word in praise of the very excellent address, which seemed to cover a scope of work of the Institution, both in engineering and shipbuilding. He might just say a word as to the American tools as compared with English tools. There was no doubt that in many points Americans had got ahead. When Americans had done anything better than we had we should give them full credit for it, copy what they had done, and then improve upon

it. He had seen many things which the Americans had done in advance of us and which we had copied and improved, with the result that things which were American had now become thoroughly English. But there were many tools that we made far better than them. He did not think that the Americans were quite so keen in copying us as we were in copying them. On account of our free trade system, and the American protective tariffs, American tools could come into England a great deal more freely than our tools could go into America. Free trade was the best thing after all for engineers. He believed that in engineering the two great crimes that did more to hinder engineers than any others were vanity and jealousy. If they could clear away these two defects, they were in the way of becoming really great engineers. They should always compare themselves with merciless fairness as to what they could do and what they could not do better than other people.

Mr. J. R. FOTHERGILL said he ventured to rise in support of the resolution, in that he particularly desired to express to the President the appreciation of the Hartlepools members in his elevation to the chair. He felt the Hartlepools members were honoured in having a townsman so well known in the shipping world as Mr. Withy elected to the presidential chair, and he was certain at the end of the President's term of office, they would realise that Mr. Withy had had most fully at heart the best interests of the Institution.

He was pleased to see the President, in his address, had referred to the necessity of apprentices acquiring a thorough practical knowledge of all details of their trade. It was well within the recollection of members they had last session a most interesting paper on this subject, and it was most satisfactory to find that employers were more fully realising the necessity and advantage of practically educating their apprentices. There was one other matter which the President referred to, and which struck him as one of very great interest and importance. The President said his firm found, after five years' experience in electric driving, the cost worked out at ·9 of a penny per Board of Trade unit, which he understood covered the total working cost, including attendance and repairs. When they considered it was generally admitted that electric driving of works paid where the current could be obtained from outside supply at 2d. to 2½d. per Board of Trade unit, which price, of course, did not cover anything but the current supply, they could not help but feel the President's firm was doing most excellent

work, and deserved their congratulations. The President pointed out the great good done by the sub-committee appointed to discuss technical subjects and advise the members of Lloyd's Committee. The Council of the Institution had from the first elected Mr Withy as one of their four representatives, and he ventured, on behalf of the members, to congratulate Mr. Withy on the great good done. In conclusion, he had very great pleasure in supporting the vote of thanks proposed by Mr. Boyd.

The vote of thanks was then put to the meeting by Mr. BOYD, and carried by acclamation.

The PRESIDENT, in reply, said of course he was not in a position to fix the 8,000 I.H.P. as the point at which twin screw machinery should be installed; that was a matter for discussion by engineers. With regard to electric driving, there was one fact which he had not given. The main engine at Middleton shipyard had been running for five years. Comparing these five years with the five previous years, taking into account the interest on capital expended upon the installation, the cost of repairs and superintendence, and comparing the cost of producing power with the wages paid, there was a saving of 47 per cent. due to electric driving. At one time his firm had five boilers, three steam engines, five winches, and two gas engines. They had gradually done away with these, and now they had two main boilers and two main engines. One of the main boilers—the usual multibular boiler, working at a pressure of 160 lbs., was sufficient for working everything on the shipyard.

The following paper "On the Stress produced in the Connecting Rod by its Motion" was read by Mr. C. H. INNES, M.A., Cantab :—

ON THE STRESS PRODUCED IN A CONNECTING ROD BY ITS MOTION.

By C. H. INNES, M.A., Cantab.

[Read before the Institution, in Newcastle-upon-Tyne, October 27th, 1900].

As the piston speed of engines is steadily increasing, and as it is important that every part of an engine should be proportioned to bear the load that it has to carry, the writer hopes that a paper on the above subject may be of interest. He intends to show the method of

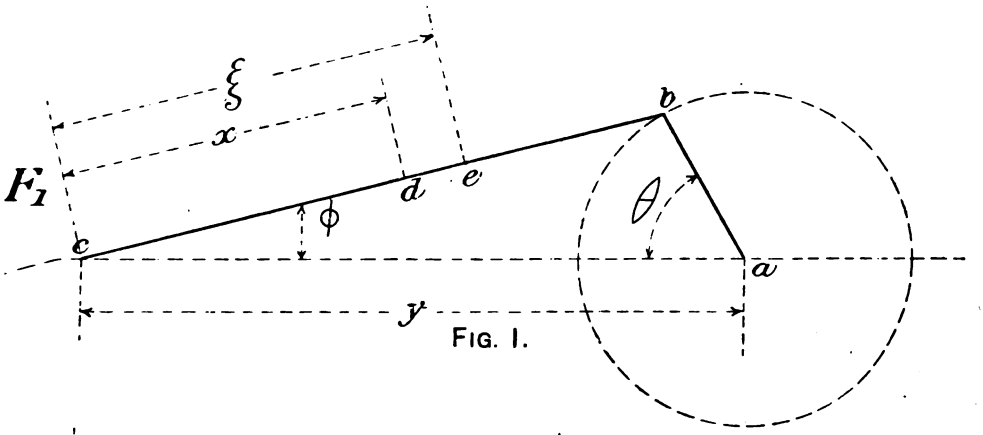


FIG. 1.

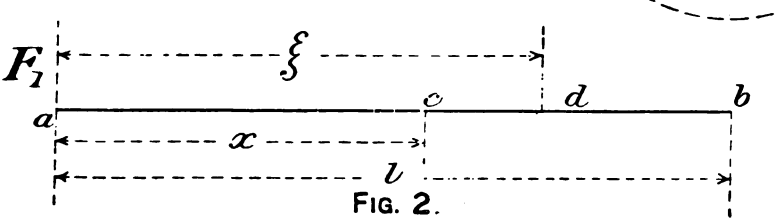


FIG. 2.

arriving mathematically at the stress, and point of greatest stress, and to give simple algebraic formulæ for calculating it for various forms of rod. In Fig. 1 are shown the centre lines of a crank *ab*, and connecting rod *bc*, *ca* being the line of stroke, while the crank is supposed to be

rotating clockways. At a point d on the rod, distant x from c, the acceleration perpendicular to the rod is, if all dimensions are in inches,

$$\frac{1}{12}(y'' \sin \phi + x\phi'') \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and it is due to this acceleration that a bending stress is produced in the rod.

If s is the cross section of the rod at d and its weight ·29lb. per cubic inch, then the force due to a small length dx is

$$\frac{\cdot 29.s.dx}{g}\left(\frac{y'' \sin \phi + x\phi''}{12}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

so that the reaction F perpendicular to bc at the point c is

$$F_1 = \int_o^l \frac{\cdot 29.s.\ dx}{g}\left(\frac{y'' \sin \phi + x\phi''}{12}\right)\frac{l - x}{l} \quad . \quad . \quad . \quad . \quad (3)$$

where l = length of the connecting rod in inches.

The section s can be expressed in terms of x, and

$$\sin \phi = \frac{r}{l}\sin \theta = \frac{1}{c}\sin \theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where r is the length of crank in inches, while

$$y'' = -r\omega^2\left(\cos \theta + \frac{\cos 2\theta}{c}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

and if ω is the angular velocity in radians,

$$\phi'' = -\frac{\omega^2.(c^2 - 1)\sin \theta}{(c^2 - \sin^2 \theta)^{\frac{3}{2}}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6).$$

We shall in future drop the minus signs, as only numerical results are required.

Thus the whole of (3) can be expressed in terms of θ and x and known constants, so that F_1 can be obtained.

The bending moment at a point e distant ξ from c can then be found.

Let this be M_e

$$M_e = F_1\xi - \int_o^\xi \frac{\cdot 29.s.\ dx.}{g}\left(\frac{y'' \sin \phi + x\phi''}{12}\right)(\xi - x) \quad . \quad (7)$$

Now the point of greatest bending moment of a beam uniformly loaded and supported at both ends is the centre, and, as shown in Appendix I., the point of greatest bending moment for a beam, on which the intensity of load is proportional to the distance from one end, that is $\propto x$ in this case, is ·58 of the length from the end having the smaller load. If the intensity of loading $\propto x^2$, the point is at ·63 of the length from the same end, and if it is $\propto x^3$ it is at ·67 of the length, as shewn in Appendix II.

In what follows, with one exception, the bending moment has been calculated at ·55 l, and all the calculations made by the writer, some of which are not given here, show that the bending moment at this point differs by a quantity of no practical importance from the maximum. The first case to be dealt with is that of a uniform rod of circular hollow section, whose external diameter is d_1, and internal d_2. The calculations in this case are given fully in Appendix III.

We summarise here the important results; let N = revolutions per minute, l = length of rod in inches, r = crank in inches and $l = cr$. Then when

$$c = 4, \quad f = \frac{l^3 N^2 d_1}{916{,}000\ (d_1^2 + d_2^2)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

$$c = 4\tfrac{1}{4}, \quad f = \frac{l^3 N^2 d_1}{977{,}500\ (d_1^2 + d_2^2)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$c = 5, \quad f = \frac{l^3 N^2 d_1}{1{,}162{,}000\ (d_1^2 + d_2^2)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$c = 6, \quad f = \frac{l^3 N^2 d_1}{1{,}405{,}000\ (d_1^2 + d_2^2)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

In the case of a solid uniform rectangular rod whose breadth is b, and depth h, the bending moment compared with that in a round rod will be increased in the ratio $\frac{bh}{\cdot 7854\ (d_1^2 - d_2^2)}$ and the resistance to bending in the ratio $\frac{16bh^2 d_1}{3\pi\ (d_1^4 - d_2^4)}$ so that the stress is altered in the ratio $\frac{3\ (d_1^2 + d_2^2)}{4h}$ so that we have when

$$c = 4, \quad f = \frac{l^3 N^2}{1{,}220{,}000\ .\ h} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

$$c = 4\tfrac{1}{4}, \quad f = \frac{l^3 N^2}{1{,}300{,}000 h} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

$$c = 5, \quad f = \frac{l^3 N^2}{1{,}550{,}000 h} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

$$c = 6, \quad f = \frac{l^3 N^2}{1{,}875{,}000 h} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

In Appendix IV. the case of a round hollow conical rod is discussed, having an internal diameter d_2 throughout, an external diameter d_1, at the small end, and d, at the large end. A numerical example is also given to show that the difference between the stress in the conical rod and a uniform rod of the same mean diameter externally and internally is very small, and of no importance to the engineer. The dimensions of

the rod are those of a torpedo boat destroyer's of the United States Navy, and are taken from the report of the United States Naval Bureau for 1898. The writer concludes from this that the formulæ for uniform rods will apply to taper rods if about 10 per cent. be added to the stress calculated for the latter.

In Appendix V. are given the calculations for a connecting rod of uniform breadth, and depth increasing uniformly from the crosshead to the crank pin end. The stress f is given by the formula when the connecting rod is six cranks long,

$$f = \frac{5328}{10^{10}} \frac{l^3 N^2 a}{h^2} + \frac{315 m l^4 N^2}{10^9 h^2} \quad \ldots\ldots\ldots (16)$$

and it will be seen that an actual example of a locomotive rod gives almost exactly the same bending stress as that in a uniform rod of the same length and mean depth. When the connecting rod is four cranks long,

$$f = \frac{8202}{10^{10}} \frac{l^3 N^2 a}{h^2} + \frac{483}{10^9} \frac{m l^4 N^2}{h^2} \quad \ldots\ldots\ldots (17)$$

and an example shews that the stress differs very little from that in a uniform rod.

In Appendix VI. is discussed the case of a rod of uniform breadth b, but increasing uniformly in depth from ends to centre. The conclusion arrived at is that the stress at ·55 l, which we have every reason for supposing not far from the point of greatest stress, is practically the same as that in a uniform rod *of the same central section if the taper is not very great.*

Appendix VII. deals with a rod of constant depth, but of breadth increasing from each end towards the centre, and the conclusion arrived at is that for a moderate taper the formulæ for uniform rods may be used. The writer thinks that the above are sufficient proofs that in all practical forms of connecting rods the stress due to bending may be calculated on the assumption that we are dealing with a uniform rod having the same section at the centre as the rod under consideration. There is yet another point to consider, viz., the deflection of the rod, because this will cause an additional bending moment when the rod is subjected to longtitudinal pressure. To calculate this would be extremely tedious, and the writer thinks that a sufficiently accurate result will be obtained by calculating the whole force perpendicular to the rod, and taking the deflection as if this load acted uniformly over its whole length, *i.e.*, if δ = deflection in inches, l = length in inches, P = above force.

$$\delta = \frac{5}{384}\frac{Pl^3}{EI}$$

where E = Young's modulus of elasticity

I = moment of inertia of section

$= \frac{bh^3}{12}$ for a rectangular section

$= \frac{\pi d^4}{64}$ for a circular solid section

$= \frac{\pi(d^4 - d_2^4)}{64}$ for a circular hollow section

$$P = \int_o^l \frac{\cdot 29}{32} s \left(\frac{y'' \sin\phi + x\phi''}{12}\right) dx$$

where s is the section at distance x from the small end. We shall only consider this for a uniform section when $\theta = 67\frac{1}{2}$ degrees, and E = 30,000,000 lbs. Then when

$$c = 4\,\delta = \frac{s.l^5 N^2}{2155 \times 10^{12} I} \text{ inches} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

$$= 5 \quad = \frac{s.l.^5 N^2}{2730 \times 10^{12} I} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

$$= 6 \quad = \frac{s.l.^5 N^2}{3430 \times 10^{12} I} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

For a rectangular rod of breadth b, depth h $\frac{s}{I} = \frac{12}{h^2}$; for a hollow circular section $\frac{s}{I} = \frac{16}{d_1^2 + d_2^2}$. The additional stress produced by this deflection is $f = \frac{W.\delta.}{Z}$ where W = load on piston, and Z modulus of section to resist bending. The calculation of δ even in high speed engines would be generally unnecessary.

APPENDIX I.

To shew that if a beam ab, Fig. 2, has a load upon it whose intensity $\propto x$ the distance from a, then the greatest bending moment is at a point $\cdot 58l$ from a.

Let F_1 = reaction at a.

$$= \int_o^l \frac{Ax.dx.(l-x)}{l} = A\frac{l^2}{6}.$$

where A is a constant.

Hence the bending moment at any point ξ from a

$$M = F_1\xi - A\frac{\xi^3}{6}. = \xi\left(\frac{A(l^2-\xi^2)}{6}\right).$$

This is a maximum when

$$\frac{dM}{d\xi} = o\ . = A\left(\frac{l^2}{6} - \frac{\xi^2}{2}\right)$$

or $\xi = \frac{l}{\sqrt{3}} = \cdot 58l$ very nearly.

APPENDIX II.

To shew that if a beam ab, Fig. 2, has a load upon it whose intensity $\propto x^2$, the distance from a squared, then the greatest bending moment is at a point $\cdot 63l$ from a.

Let F_1 be the reaction at a.

$$= \int_o^l \frac{A\,x^2(l-x)\,dx}{l.} = \frac{Al^3}{12.}$$

Hence the bending moment at any point ξ from a,

$$M = F_1\xi - \frac{A\xi^4}{12} = \frac{A\xi}{12}(l^3 - \xi^3).$$

This is a maximum when

$$l^3 - 4\xi^3 = o\ ; \quad \xi = \frac{l}{\sqrt[3]{4}} = \cdot 63l.$$

Similarly it may be shewn that if the intensity of the load $\propto x^3$ then

$$\xi = \frac{l}{\sqrt[4]{5}} = \cdot 67l.$$

APPENDIX III.

Bending moment and stress in a round hollow cylindrical rod, external diameter d_1, internal d_2.

$$F_1 = \cdot 29 \times \frac{\pi d_1^2}{4g}\left(1 - \left(\frac{d_2}{d_1}\right)^2\right)\int_o^l \frac{y''\sin\phi}{12} + \frac{x\phi''}{l}(l-x)\,dx.$$

$$= \cdot 29\frac{\pi d_1^2}{4gl}\rho\left[y''\sin\phi\,.\,\frac{l^2}{24} + \frac{\phi'' l^3}{72}\right] \text{ where } \rho = 1 - \left(\frac{d_2}{d_1}\right)^2$$

The bending moment at $\cdot 55l$,

$$M = \cdot 55\,F_1.\,l. - \cdot 29\,\frac{\pi d_1^2}{4g}\rho\int_o^{\cdot 55l} \frac{y''\sin\phi}{12} + \frac{x\,\phi''}{12}(\cdot 55l - x)\,dx.$$

$$= \frac{\cdot 29\ \pi\ d_1^2\ \rho}{4g}\left\{\frac{\cdot 55 \times \cdot 15.\ l^2\ y''\sin\phi}{24} + \frac{\cdot 55 \times \cdot 6975\ l^3\ \phi''}{72}\right\}$$

Let f = stress per sq. inch in lbs.

$$= \frac{32 \cdot M \cdot d_1}{\pi(d_1^4 - d_2^4)}.$$

$$= \frac{\cdot 000748\, l^2 y'' \sin\phi + \cdot 000387\, l^3 \phi''}{d_1^2 + d_2^2} d_1.$$

To obtain formulæ for this, when the connecting rod is 4, 4¼, 5, and 6 cranks, let r be the crank in inches, and let $l = c \cdot r$.

First let $c = 4$. $\cos\theta = \cdot 574$, $\sin\theta = \cdot 819$ when $\theta = 55°$, $\cos 2\theta = -\cdot 342$, $\sin^2\theta = \cdot 67$.

$$f = \frac{d_1}{d_1^2 + d_2^2} \left\{ \frac{\cdot 000748}{4} \left(l^2 \omega^2 \left(\cos\theta + \frac{\cos 2\theta}{4}\right) \frac{\sin\theta}{4} + \frac{l^3 \omega^2 \cdot \sin\theta \times 15 \times \cdot 000387.}{(16 - \sin^2\theta)^{\frac{3}{2}}} \right) \right\}.$$

$$= \frac{l^3 N^2 d_1}{d_1^2 + d_2^2} \left\{ \cdot 000000205 + \cdot 000000869 \right\}$$

$$= \frac{l^3 N^2 d_1}{d_1^2 + d_2^2} \times \cdot 000001074.$$

where N = revolutions per minute.

When $\theta = 60°$

$$f = \frac{l^3 \omega^2 d_1}{d_1^2 + d_2^2} \left\{ \frac{\cdot 000748}{4} \cdot (\cdot 5 - \cdot 125) \cdot \frac{\cdot 865}{4} + \frac{\cdot 865 \times 15 \times \cdot 000387.}{15 \cdot 25 \times 3 \cdot 9} \right\}$$

$$= \cdot 000001091 \frac{l^3 N^2 d_1}{d_1^2 + d_2^2}.$$

When $\theta = 67\frac{1}{2}°$

$$f = \cdot 000001092 \frac{l^3 N^2 d_1}{d_1^2 + d_2^2}.$$

so that the maximum stress for a uniform rod when $c = 4$ is $\frac{l^3 N^2 d_1}{916{,}000 \quad (d_1^2 + d_2^2)}$. when θ is about $67\frac{1}{2}°$.

When $c = 4\frac{1}{4}$,

$$f = \frac{l^3 N^2 d_1}{977{,}500 \quad (d_1^2 + d_2^2)}. \text{ when } \theta = 67\tfrac{1}{2}°.$$

When $c = 5$,

$$f = \frac{l^3 N^2 d_1}{1{,}162{,}000 \quad (d_1^2 + d_2^2)}. \text{ when } \theta = 67\tfrac{1}{2}°.$$

When $c = 6$,

$$f = \frac{l^3 N^2 d_1}{1{,}405{,}000 \quad (d_1^2 + d_2^2)}. \text{ when } \theta = 67\tfrac{1}{2}°.$$

APPENDIX IV.

To find a formula for the bending moment at the centre of a conical rod whose diameter at the small end is d_1, at the large end is d_2, and whose internal diameter is d_3. All dimensions are given in inches

$$d_2 = (1 + ml)\, d_1$$

and if d is the diameter at a distance x from the small end

$$d = (1 + mx)\, d_1.$$

$$\text{Also let } p = 1 - \left(\frac{d_3}{d_1}\right)^2.$$

Then the weight of a small length dx at a distance x from the small end is

$$\cdot 29 \times \cdot 7854\, d_1^2\, (p + 2mx + m^2x^2)\, .\, dx.$$

and F_1 (see Fig. 1)

$$= \frac{\cdot 7854 \times \cdot 29\, d_1^2}{g} \int_o^l (p + 2mx + m^2x^2) \left(\frac{x\phi'' + y'' \sin\phi}{12}\right) \frac{l-x}{l} dx.$$

$$= \frac{\pi}{4} \times \frac{\cdot 29 d_1^2}{12gl} \int_o^l \left\{ \begin{array}{l} px\,\phi'' + 2mxy'' \sin\phi + py'' \sin\phi + 2mx^2\,\phi'' \\ \qquad + m^2x^2y'' \sin\phi + m^2x^3\,\phi'' \end{array} \right\} (l-x)\, dx.$$

$$= \frac{\pi}{4} \times \frac{\cdot 29 d_1^2}{12gl} \left\{ \begin{array}{l} l^2py'' \sin\phi + \frac{l^2}{2}(2mly'' \sin\phi + p\phi''l - py'' \sin\phi) \\ \quad + \frac{l^3}{3}(lm^2y'' \sin\phi + 2ml\,\phi'' - 2my'' \sin\phi - p\phi'') \\ \quad + \frac{l^4}{4}(lm^2\,\phi'' - m^2y'' \sin\phi - 2m\,\phi'') - \frac{m^2\,\phi''\,l^5}{5} \end{array} \right\} = F_1$$

$$= \frac{\cdot 29 d_1^2\, \pi}{48gl} \left\{ y'' \sin\phi \left(p\,\frac{l^2}{2} + \frac{1}{3}ml^3 + \frac{1}{12}m^2l^4\right) + \phi'' \left(p\,\frac{l^3}{6} + \frac{ml^4}{6} + \frac{m^2l^5}{20}\right) \right\}$$

Now the bending moment at the centre $= F_1 \frac{l}{2}$ — moment of all the forces on half the rod ce about e the centre. But the moment of all these latter is

$$\frac{\cdot 29 \frac{\pi}{4} d_1^2}{12g} \int_o^{\frac{l}{2}} (p + 2mx + m^2x^2)\, (x\,\phi'' + y'' \sin\phi) \left(\frac{l}{2} - x\right) dx$$

Hence this integral is the same as the integral to obtain F_1, except that we first have to substitute $\frac{l}{2}$ for l everywhere in F_1 and then multiply by $\frac{l}{2}$, so that

$$\text{bending moment at centre} = \frac{\cdot 29 d_1^2 \pi}{48g} \left\{ \begin{array}{l} y'' \sin\phi \left[p \left(\frac{l^2}{4} - \frac{l^2}{8}\right) + \frac{1}{3} m \left(\frac{l^3}{2} - \frac{l^3}{8}\right) \right. \\ \left. \quad + \frac{m^2}{12} \left(\frac{l^4}{2} - \frac{l^4}{16}\right) \right] + \phi'' \left[\frac{pl^3}{12} - \frac{pl^3}{48} + \frac{m}{6} \left(\frac{l^4}{2} - \frac{l^4}{16}\right) + \frac{m^2}{20} \left(\frac{l^5}{2} - \frac{l^5}{32}\right) \right] \end{array} \right\}$$

$$= \frac{\cdot 29 d_1^2 \pi}{48g} \left\{ y'' \sin\phi \left[p\,\frac{l^2}{8} + \frac{ml^3}{8} + \frac{7m^2l^4}{192} \right] + \phi'' \left[\frac{pl^3}{16} + \frac{7ml^4}{96} + \frac{3m^2l^5}{128} \right] \right\}$$

The following is a numerical example: the connecting rod belongs to a torpedo boat destroyer of the U.S. Navy. The diameter of the h.p. cylinder is 20½ ins.; the stroke is 22 ins.; revolutions per minute, 327; boiler pressure, 300, reduced to 250 at the engines; length of rod, 46¾ ins.; diameter at large end, 4⅝, and at small end, 3⅞ ins.; internal diameter, 2¼ ins.; mean diameter, 4·21 ins. The diameters given near large and small ends are at 9½ ins. from the former and 12 ins. from the latter, so that if the conical surface were produced it would give a diameter of 4·905 inches at the large end and 3·518 at the small. The real ends are neglected and these ends are put in their places to allow of mathematical treatment. The external diameter of the rod d at a distance of x inches is given by the formula $d = 3{\cdot}518\ (1 + {\cdot}00834x)$ so that $m = {\cdot}00834$. Then $d_1^2 = 12{\cdot}4$ nearly, $p = {\cdot}59$, $m^2 = {\cdot}0000695$, so that the bending moment at the centre = M

$$= \frac{{\cdot}1125\pi}{48}\left\{ y'' \sin\phi \left({\cdot}59\frac{l^2}{8} + \frac{{\cdot}00834 l^3}{8} + \frac{7 \times {\cdot}0000695 l^4}{192} \right) + \phi'' \left(\frac{{\cdot}59 l^3}{16} + \frac{7 \times {\cdot}00834 l^4}{96} + \frac{3 \times {\cdot}0000695 l^5}{128} \right) \right\}$$

$$= 2{\cdot}05\, y'' \sin\phi + 51{\cdot}7\, \phi''$$

y' being expressed in inches.

The modulus at the centre to resist bending is

$$\frac{\pi}{32} \cdot \frac{4{\cdot}21^4 - 2{\cdot}25^4}{4{\cdot}21} = 6{\cdot}75 = Z_1$$

$$y'' = r\varpi^2 \left(\cos\theta + \frac{\cos 2\theta}{c} \right) \phi'' = \varpi^2 \frac{(c^2 - 1)\sin\theta}{(c^2 - \sin^2\theta)^{\frac{3}{2}}}$$ disregarding minus signs.

$\varpi^2 = 1170$, $r\varpi^2 = 12870$., $c^2 - 1 = 17{\cdot}02$, $(c^2 - 1)\varpi^2 = 19900$.

so that when $\theta = 45°$ $\dfrac{M}{Z} = 1933$. = stress at centre

$\theta = 60°$ $\dfrac{M}{Z} = 2149$ = stress at centre

$\theta = 75°$ $\dfrac{M}{Z} = 2119$. = stress at centre

$\theta = 90°$ $\dfrac{M}{Z} = 1954$. = stress at centre.

Comparing this with a rod of uniform section having the mean diameter of 4·21 inches we get (since $m = o$) $M = 47{\cdot}9\ \phi'' + 2{\cdot}046\ y'' \sin\phi$.

$$\text{Stress at centre} = \frac{M}{Z} = \frac{47{\cdot}9\,\phi + 2{\cdot}046\, y'' \sin\phi}{6{\cdot}75}$$

so that when $\theta = 45°$ stress at centre = 1820.

$\theta = 60°$ stress at centre = 2003.

$\theta = 75°$ stress at centre = 1969.

$\theta = 90°$ stress at centre = 1804.

so that the stress in the conical rod is only about 10 per cent. greater, although the ratio of section of large end to small is 1·9 : 1.

APPENDIX V.

Connecting rod of uniform breadth b, and depth increasing uniformly from the crosshead end to the crank pin end.

The depth at a distance x from the small end is $a + mx$, a being the depth at that end.

$$F_1 = \int_0^l \frac{\cdot 29}{12g}(a + mx)\, b(y'' \sin\phi + x\phi'')\frac{l-x}{l}dx.$$

$$= \frac{\cdot 29}{12g}\frac{b}{l}\left\{ l^2 ay'' \sin\phi + \frac{l^2}{2}\left(al\,\phi'' - ay'' \sin\phi \times mly'' \sin\phi\right)\right.$$

$$\left. + \frac{l^3}{3}\left(ml\,\phi'' - my'' \sin\phi - a\phi''\right) - \frac{ml^4}{4}\phi''\right\}$$

$$= \frac{\cdot 29b}{12g}\left\{\frac{l}{2}ay'' \sin\phi + \frac{1}{6}al^2\phi'' + \frac{1}{6}ml^2y'' \sin\phi + \frac{1}{12}ml^3\phi''\right\}$$

Now if we write for l, $(1 - \cdot 55l) = \cdot 45l$.

$$\text{for } l^2, \left[1 - (\cdot 55l)^2\right] = \cdot 6975l^2$$

$$\text{for } l^3, \left[1 - (\cdot 55l)^3\right] = \cdot 834l^3$$

and multiply the above by $\cdot 55l$ we obtain the bending moment at $\cdot 55$ length from the small end. This gives

$$M = b\{y'' \sin\phi\,(\cdot 0000932\, la^2 + \cdot 0000482\, ml^3) + \phi''\,(\cdot 0000482\, al^3 + \cdot 0000288\, ml^4)\}.$$

When $\theta = 67\frac{1}{2}°$, $c = 6$, $f = \frac{M}{Z}$, where $Z = \frac{bh^2}{6}$ the moment of resistance to bending at $\cdot 55l$,

$$f = \frac{l^3N^2a}{h^2}\cdot\frac{5328}{10^{10}} + \frac{315ml^4.N^2}{10^9\,h^2}.$$

If we take, as an example of this, a locomotive rod in which $l = 78$ ins., N = 300 revs. per minute; depth at small end $= a = 3\frac{1}{2}$, at large end $= 5$, $h =$ mean depth $= 4\frac{1}{4}$, $m = \frac{5 - 3\frac{1}{2}}{78} = \cdot 01925$.

$$f = 5527.$$

Equation (15) for a uniform rod of the same length and mean depth gives us:

$$f = \frac{l^3N^2}{1875000\,h} = 5360.$$

If $c = 4$ then $f = \frac{l^3 N^2 a}{h^2} \cdot \frac{8202}{10^{10}} + \frac{483}{10^9} \frac{ml^4 N^2}{h^2}$, and applying this to the case in which $c = 4$, $l = 78$ ins., $N = 300$ revs., $a = 3\frac{1}{2}$, $h = 4\frac{1}{4}$, $m = \cdot 01925$,

$$f = 8395,$$

while from a uniform rod from (12) it is

$f = 8225$, which is practically the same.

This example is not taken from practice.

APPENDIX VI.

To find the formulæ for the stress in a rod of uniform breadth whose depth at the crosshead end is h_1, at the centre $h_2 = h_1 + \frac{1}{2}ml$, and at the crank end $h_3 = h_2 - m_1 \frac{l}{2}$, its greatest depth being h_2 at the centre and its taper uniform.

$$\text{Firstly } F_1 = \int_o^{\frac{l}{2}} \frac{\cdot 29bh}{12 \times 32} (y'' \sin\phi + x\phi'') \frac{l-x}{l} dx$$

$$+ \int_{\frac{l}{2}}^{l} \frac{\cdot 29bh}{12 \times 32} (y'' \sin\phi + x\phi'') \frac{(l-x)}{l} dx \text{ . all dimensions being in inches.}$$

$$= \int_o^{\frac{l}{2}} \frac{\cdot 29b}{12 \times 32} (h_1 + mx)(y'' \sin\phi + x\phi'') \frac{l-x}{l} dx .$$

$$+ \int_{\frac{l}{2}}^{l} \frac{\cdot 29b}{12 \times 32} \left\{ h_2 - m_1 \left(x - \frac{l}{2} \right) \right\} (y'' \sin\phi + x\phi'') \frac{l-x}{l} dx .$$

$$= \frac{\cdot 29b}{12 \times 32l} \int_o^{\frac{l}{2}} \left\{ \begin{array}{l} h_1 l y'' \sin\phi + x(mly'' \sin\phi - h_1 y'' \sin\phi + h_1 l\phi'') \\ \quad + x^2 (ml\phi'' - my'' \sin\phi - h_1\phi'') - mx^3\phi'' \end{array} \right\}$$

$$+ \frac{\cdot 29b}{12 \times 32l} \int_{\frac{l}{2}} \left\{ \begin{array}{l} h_4 y'' l \sin\phi + x(h_4 l\phi'' - m_1 l y'' \sin\phi - h_4 y'' \sin\phi) \\ \quad + x^2 (m_1 y'' \sin\phi - ml\phi'' - h_4\phi'') + m_1 x^3 \phi'' \end{array} \right\}$$

where $h_4 = h_2 + \frac{1}{2} m_1 l$.

$$= \frac{\cdot 29b}{12 \times 32l} \left\{ \begin{array}{l} h_1 y'' \frac{l^2}{2} \sin\phi + \frac{1}{8} l^2 (mly'' \sin\phi - h_1 y'' \sin\phi + hl\phi'') \\ \quad + \frac{1}{24} l^3 (ml\phi'' - my'' \sin\phi - h_1\phi'') - ml^4\phi'' \end{array} \right\}$$

$$+ \frac{\cdot 29b}{12 \times 32l} \left\{ \begin{array}{l} h_4 y'' \frac{l^2}{2} \sin\phi + \frac{3}{8} l^2 (lh_4\phi'' - m_1 l y'' \sin\phi - h_4 y'' \sin\phi) \\ \quad + \frac{7}{24} l^3 (m_1 y'' \sin\phi - m_1 l\phi'' - h_4\phi'') + \frac{15 m_1 l^4 \phi''}{64} \end{array} \right\}$$

The maximum bending moment is evidently nearer the centre than for a uniform rod, and it is also to the right of the centre. Hence we

shall still assume that it is a maximum at $\cdot 55l$. The bending moment

$$M = \cdot 55\, F_1 l - \int_o^{\frac{l}{4}} \frac{\cdot 29b}{12 \times 32} (h_1 + mx)(y'' \sin\phi + x\phi'')(\cdot 55l - x)dx$$

$$- \int_{\frac{l}{4}}^{l} \frac{\cdot 29b}{12 \times 32} (h_4 - m_1 x)(y'' \sin\phi + x\phi'')(\cdot 55l - x)dx.$$

$$= \frac{\cdot 29b}{32} \left\{ \begin{array}{l} y'' \sin\phi(\cdot 00466\, h_1 l^2 + \cdot 0056\, l^2 h_4 + \cdot 00155\, ml^3 \\ \qquad - \cdot 00374 m_1 l^3) \\ \quad + \phi''(\cdot 001555\, h_1 l^3 + \cdot 0038 h_4 l^3 \\ \qquad + \cdot 000582\, ml^4 - \cdot 002618\, m_1 l^4) \end{array} \right\}$$

where all dimensions are in inches.

The stress at $\cdot 55l$ will be found by dividing the above by $\frac{bh_5^2}{6}$ where h_5 = depth at $\cdot 55$ length. A numerical example has been worked out in which $h_1 = 3\frac{1}{2} = h_3$, $m = \cdot 01925$., $l = 78''$, $c = 6$, $h_2 = 4\frac{1}{4}$, $h_4 = 5$, $h_5 = 4\cdot 24$, N = 300, $\varpi = 10\pi$. which gives us

$$f = 12\cdot 12\, y'' \sin\phi + 30\cdot 7\, \phi''.$$

and this is greatest when $\theta = 67\frac{1}{2}$. and = 5367. so that it is practically the same as that in a uniform rod of the same central section if the taper is moderate.

APPENDIX VII.

In a rod of constant depth h, but of varying breadth b_1, being that at the small end, b_2 that at the centre, b_3 that at the large end, the breadth varying uniformly from ends to centre, the bending moment at $55l$,

$$M = \frac{\cdot 29h}{32} \left\{ \begin{array}{l} y'' \sin\phi(\cdot 00466 b_1 l^2 + \cdot 0056\, b_4 l^2 + \cdot 00155\, ml^3 \\ \qquad - \cdot 00374\, m_1 l^3) \\ \quad + \phi''(\cdot 001555\, b_1 l^3 + \cdot 0038\, b_4 l^3 + \cdot 000582 ml^4 \\ \qquad - \cdot 002618\, m_1 l^4) \end{array} \right\}$$

where $b_4 = b_2 + \frac{1}{4} m_1 l$.

The stress is obtained by dividing the above by $\frac{b\,h^2}{6}$. where b_5 = breadth at $\cdot 55l$.

As an example of this $l = 40''$, crank = $9''$, revs. per min. = 350, $h = 4\cdot 375''$, $b_1 = 1\frac{1}{4}''$, $b_2 = 2''$, $b_3 = 1\frac{1}{4}''$, $b_4 = 2\frac{3}{4}''$, $m = m_1 = \cdot 0375$, $c = 4\cdot 45$.

$$f = 1187, \text{ when } \theta = 67\tfrac{1}{2}^\circ.$$

Now for a uniform rod $4\frac{1}{4}$ times the crank with a depth and length the same as the above at the centre and running at the same number of revolutions $f = 1375$, and if $c = 5$ $f = 1150$. Hence it is clear that if the rod is $4\cdot 45$ times the crank f is not very far from 1187, so that formulæ for uniform rods may be used in this case.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SEVENTEENTH SESSION, 1900-1901.

PROCEEDINGS.

SECOND GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE SUNDERLAND LITERARY SOCIETY, SUNDERLAND, ON FRIDAY EVENING, NOVEMBER 16TH, 1900.

HENRY WITHY, ESQ., J.P., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of last General Meeting, held in Newcastle, on October 27th, 1900, which were approved by the members present, and signed by the President.

The ballot for new members having been taken, the President appointed Mr. Robt. Thompson and Mr. R. H. Muir to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Anderson, Charles William, Jun., Ship Draughtsman, Mandale House, Mandale Road, Thornaby-on-Tees.

Borrie, Peter, Engineer, 4, Oxford Terrace, Stockton-on-Tees.

Davidson, Alexander, Jun., Engineer Draughtsman, 15, North View, Heaton, Newcastle-upon-Tyne.

Foster, Martin, Forge Master, Claremont, Norton, Stockton-on-Tees.

Gibson, William Wright, Shipbuilder, 162, Roker Avenue, Sunderland.

Higginbotham, George Emerton, Engineer Draughtsman, Swiss Villa, Benton, Newcastle-upon-Tyne.

Lund, Pearson, Engineer, Messrs. Noble & Lund, Northern Machine Tool Works, Felling-on-Tyne.

Milton, James Edward, Engineer Surveyor, Messrs. Lloyds' Register of Shipping, 3, St. Nicholas Buildings, Newcastle-upon-Tyne.

Ostens, Joseph, Engineer Draughtsman, 4, Jackson Street, North Shields.

Ranken, David, Engineer Superintendent, Azalea Terrace, Sunderland.

Riseley, Harry Lorimer, Engineer, 10, Renfrew Road, Wallsend-on-Tyne.
Shaw, Thomas, Engineer Surveyor, Messrs. Lloyds' Register of Shipping, 3, St. Nicholas Buildings, Newcastle-upon-Tyne.
Swainston, William, Forge Master, 69, Warwick Street, Heaton, Newcastle-upon-Tyne.
Thompson, Ernest Routledge, Engineer Draughtsman, 25, St. Thomas' Crescent, Newcastle-upon-Tyne.
Watts, James Arthur, Engineer, 16, Westoe Parade, South Shields.
Webster, William Milne, Engineer, 23, North View Heaton, Newcastle-upon-Tyne.
Williams, M. Lucas, Engineer, 19, Barratt Street, Stockton-on-Tees.

ASSOCIATES.

Armstrong, Thomas Henry, Engineer's Agent, Blanchland House, Willington-Quay-on-Tyne.
Rimer, William Thomas, Merchant, Craigielea, Low Fell, Gateshead-on-Tyne.

GRADUATES.

Bowerbank, Albert William, Engineer Draughtsman, 48, Walker Terrace, Gateshead-on-Tyne.
Crewe, Veve, Engineer Draughtsman, 73, Heaton Park Road, Newcastle-upon-Tyne.
Crow, William George, Engineer Apprentice, 47, Rye Hill, Newcastle-upon-Tyne.
Woods, Arthur, Engineer Student, Mitford House, Wilfred Terrace, Whitley Bay, Northumberland.

Mr. E. L. ORDE read a paper on "Liquid Fuel."

LIQUID FUEL.

By E. L. ORDE.

[Read before the Institution in Sunderland on November 16th, 1900.

The early history of liquid fuel has been so ably put before this Institution by the late Mr. B. G. Nichol, and later in the admirable paper of Mr. Wallis, that there is no need to-day to recapitulate what has been done up to the present time with this form of combustible. The writer, however, ventures to think that the practical results of some experiments with which he was entrusted, and the conclusions to which they have led, may not be without interest to the members of this Institution, and may at all events form the basis of a profitable and interesting discussion. It is only within the last few years that liquid fuel has come within the province of engineers in this country, owing to the fact that hitherto it has only been practically obtainable in the vicinity of the Caspian Sea at such a price as renders it commercially possible. Within the last few years, however, a considerable change has taken place. New oil fields have been discovered, and the number of places along the Eastern route at which liquid fuel can be obtained has increased so enormously that it becomes a serious question for shipowners to consider whether it is not an absolute economy to use it in preference to coal on vessels trading to the Eastward. The solution of this question lies first in the cost of the fuel and its practical calorific value as compared with coal; secondly, in its effect on the life of the boiler furnaces in which it is burnt; and thirdly, perhaps the most important of all, its immunity from danger. The first point is, of course, constantly varying, and is one which the writer is not in a position to pursue. The two latter practically resolve themselves into one—the efficient combustion of the fuel. The existing appliances designed for the purpose may be broadly divided into three.

1st. Those in which the liquid fuel is injected into the furnace in the form of a spray by purely mechanical means.

2nd. Those in which the spray is produced by the introduction of a gaseous medium.

And 3rd. Where the liquid fuel is introduced into the furnace in the form of vapour.

Before considering the respective merits of these three classes of apparatus, it will be advantageous to realize the actual possibilities of the fuel. The experiments which the writer carried out were made with crude Borneo oil, which is in all respects an excellent fuel oil, and is to be obtained in large quantities. Its composition is :—

Carbon	...	87·9 per cent.
Hydrogen		10·78 ,,
Oxygen	...	1·24 ,,

The flash point is 211° F.; the boiling point is 395° F. The calorific value determined by the Bomb calorimeter is 18831 B.T.U. It is an exceptionally clean and mobile fuel oil, and with its high flash point the risk of adventitious explosion is reduced to a minimum. All fuel oils are exceedingly complex, inasmuch as they are made up of a number of combinations of carbon and hydrogen which only a chemist who has devoted himself to investigating hydrocarbons can appreciate at their true significance. The importance of this point for the practical purposes of the engineer lies in the fact that the various constituents of the fuel give off vapour at temperatures varying from about 100° F., up to the boiling point of the oil, and when the boiling point is approached —unless special precautions are taken—a residue of solid carbon is formed which will soon choke any pipes or narrow passages through which the fuel may have to pass. Having thus considered the characteristics of a typical fuel oil, we may now return to the consideration of the apparatus for burning it.

In the first type, the purely mechanical spray, the oil is discharged under pressure into what is commonly called a burner, which is made of such a form that the effluent jet is broken up into particles sufficiently small to burn readily at the firing point of the fuel. The full efficiency of the system can only be obtained by lining the furnace with fire-bricks, or other non-conducting material, so as to raise the furnace temperature (by preventing the absorption of heat into the boiler) until it is sufficiently high to vaporize the greater portion of the oil before it is burned. The quantity of air required to complete combustion is very largely in excess of what is chemically necessary, and the furnace space required for oxidation is large. The advantages of the system are: first, its simplicity; and secondly, its noiselessness.

As regards efficiency the best results that the writer has been able to

find recorded show an evaporative efficiency of about 12·5 lbs. of water from and at 212° per lb. of oil. With Borneo oil this gives a fuel efficiency of 64·6 per cent.

In the second class the oil is introduced into the furnace in the form of a spray in the presence of a gaseous medium —be it steam or air. In most of these appliances a partial lining of fire-brick is fitted in the furnace, and a brick bridge or baffles of various forms are built with a view of obtaining complete oxidation of the fuel. The earliest form of this apparatus consisted simply of two pipes lying one above the other, and having their ends flattened so as to spread the streams of oil and steam. Oil is admitted to the upper pipe and is allowed to drop from the orifice into the jet of steam which passes through the lower pipe and meeting the oil breaks it up into particles sufficiently small to ignite as soon as the firing point is reached. This simple device has been improved upon by numbers of engineers, and most of the improved burners of this type take the form of concentric tubes, through which the oil and steam are passed. Adjusting arrangements are always provided, so that the supply of the two elements can be regulated at will. This type is better known than any other, and has, so far, given the best results. The evaporative efficiency of the best burners of this type seems to be about 13 to 14 lbs. from and at 212°, but the supply of air required for oxidation though smaller than that demanded by the first class of burner is much above what is chemically necessary. The difference between steam and air as spraying media will be touched upon hereafter. The third class of apparatus, that is in which the fuel oil is wholly or partially vaporized, promises to give the best results.

Attempts have been made so long ago as 1867 to produce an apparatus on the system, and Colonel Foote claimed remarkable results for his method of solving the problem; these results, however, seem not to be well authenticated. Later, Messrs. Dorsett and Blyth attempted to boil the fuel in one boiler and burn the resultant vapour in the furnace of another. This, however, does not seem to have been very successful. Mr. Thwaite has since then made an apparatus consisting of a retort which is maintained at a red heat, and into the retort a spray of steam and oil is blown; the oil is immediately volatilized and passes through holes in the retort into the furnace where it is met by a stream of air in which the vapour burns with a clear blue flame. The results are said to be satisfactory, but it is difficult to see how such a process can be carried out with ordinary fuel oils without producing a large deposit of carbon in some form in the retort.

An experiment tried by the writer with an apparatus on this principle showed that it was possible to produce a high furnace temperature and a smokeless fire, but the retort was soon completely choked with solid carbon, or, if the temperature was allowed to fall, with a pitch-like substance. This deposit presents the greatest difficulty in the way of completely vaporizing so complex a body as the ordinary fuel oil. As has been pointed out before, the oil consists of a number of hydrocarbon combinations, each of which has a different boiling point.

Another important characteristic of these hydrocarbon compounds is that in the presence of superheated steam, they can be completely distilled without cracking, and the explanation of this fact (on which depends the Ragosine process for refining petroleum) has been stated to be that in the presence of superheated steam, the boiling point, or more correctly, the mean boiling point, of the oil is lowered. This distillation, however, does not apparently take place with any other medium but steam.

To ensure distillation it is necessary that the temperature of the oil should be raised to as near the boiling point as possible before it is admitted into the presence of the steam, and it is in this part of the process that the danger of cracking appears. In the apparatus fitted by the firm with which the writer is connected the difficulty has been overcome, and so far as it has been possible to ascertain by ordinary means, complete vaporization has been secured. The vapour thus produced can be completely oxidised by the amount of air chemically necessary, and a larger quantity of oil can therefore be treated in the same furnace space than by either of the two other systems, while the combustion as shewn by the analysis of the waste gases is complete.

Two typical analyses are given below :—

Analysis of Waste Gases.			Analysis of Waste Gases.		
Carbon dioxide	=	13·2 %	Carbon dioxide	=	12·6 %
Oxygen	=	3·6 ,,	Oxygen	=	4·0 ,,
Carbon monoxide	=	0·0 ,,	Carbon monoxide	=	0·0 ,,
Hydrocarbon gases	=	0·0 ,,	Olefines, &c.	=	0.0 ,,
Hydrogen	=	0.0 ,,	Hydrogen	=	0·0 ,,
Nitrogen	=	83·2 ,,	Nitrogen	=	83·4 ,,
		100·0 %			100·0 %

The only feature calling for remark is the somewhat large percentage of uncombined oxygen, which is no doubt due to leakage around the smokebox. As regards efficiency an evaporation of from 15-16 lbs. from and at 212° should always be obtained with dry Borneo oil.

The hydrocarbon vapour is exceedingly unstable and appears to depend for its existence entirely on temperature. Efforts have been made to collect samples for analysis, but without success. In appearance it is of almost milky whiteness, closely resembling the vapour given off from the retort used in the Pintsch gas system. The smell is pungent, and severe irritation is set up in the membranes of the mouth and throat if the vapour is inhaled.

At the temperature of the external air (60°) it was found almost impossible to ignite it, and the outer surface of the jet was at once condensed and formed an oil deposit of a very much lighter colour than the fuel oil itself.

The flame when the vapour is burned in a boiler furnace over a layer of broken fire-brick is of dazzling whiteness and becomes almost transparent as it approaches the bridge.

The exact form in which the combustion of these hydrocarbon vapours takes place does not seem to be clearly understood.

The appearance of the flame at a distance of a few inches from the nozzle of the burner suggests that at that point the hydrocarbons are burning in the form of acetylene.

All gaseous hydrocarbons when exposed to a temperature of 1,000° F. become acetylene, and it seems fair to assume that the vapour will do the same. As the flame proceeds further into the furnace, however, and the temperature becomes higher, the hydrocarbon combination must break up and the rest of the vapour is probably burned as carbon monoxide and hydrogen.

This theory is put forward with diffidence in the hope that the reaction which takes place may be more worthily dealt with in discussion.

There seems to be no doubt that the efficiency of liquid fuel lies in the fact that it is capable of being turned into vapours of high calorific power, and that the vaporizing process does not demand a large heat expenditure.

The two classes of apparatus first described do not vaporize the fuel before combustion begins, which means that of the heat generated in the furnace some considerable part is absorbed for this purpose, and is therefore not available for evaporating water. To attain to the temperatures required for complete vaporization, part, at all events, of the constituents must be exposed to the heat of the furnace, but with careful design the quantity of heat thus abstracted can be reduced considerably below that which is necessary to carry out the process when the fuel is simply injected into the furnace as spray. The fact that superheated

steam lowers the boiling point of hydrocarbon oils, and therefore prevents cracking, renders its employment essential if it is desired to burn the fuel as vapour. The objection to using it on board ship is, of course, the loss of fresh water and the amount of heat lost in making this loss good by distilling sea-water; this loss, however, is, the writer ventures to think, more than compensated by the gain in efficiency due to using steam as a distilling agent. Mr. Morison has published some calculations of the quantity of fuel required for distilling purposes, and applying these calculations to a steamer with engines indicating 2,000 H.P. at sea, the quantity of oil fuel required to make up in the evaporator the water lost in the burners only amounts to one quarter of a ton per day of 24 hours. In this calculation Mr. Morison's calculated result has been multiplied by *four* to allow for deposit on the surface of the evaporating coils.

With air as a spraying agent, there is, of course, no loss of fresh water, but it is questionable whether the quantity of steam used in the air compressors is not greater than that required in the burners and evaporators together. The complete combustion of petroleum spray depends firstly on the correct relation between the volumes of the oil and the spraying agent, and secondly, on the velocity of the spraying agent, both of which requirements place air at a considerable disadvantage as compared with the steam. The general conclusions produced from the investigations the writer has made are as follows :—

(1) Liquid fuel of good quality, such, for instance, as Borneo oil, used in boiler furnaces, if efficiently treated, should show a reduction in consumption of about 40 per cent. as compared with coal.

(2) A reduction in bunker space of about 15 per cent. for the same weight of fuel; a reduction of about 50 per cent. for the same radius of action.

(3) A reduction in the stokehold staff of at least 50 per cent.

The advantages of liquid fuel as regards ease of manipulation, cleanliness, absence of smoke, reduced temperature of stokehold as compared with coal, increased life of boilers owing to constant temperature, improved performance of engines owing to constant steam pressure, need not be enlarged upon to the members of this Institution, but the question of immunity from danger requires some consideration. With a fuel oil of which the flash point is 200° F. or over, there should be no risk of

explosion whatever, and, unless there is want of ordinary care in the management of the burning apparatus and the fuel supply, the danger of fire ought not to exist. Still, fires have occurred, and it may be well to consider the causes from which they have originated.

The most fruitful cause appears to be intermittent action of the burning apparatus. This may arise from dirt in the oil or from the presence of water. To get rid of the dirt it is only necessary to provide an efficient filtering apparatus, and this should form a part of all liquid fuel installations. The second cause, the presence of water, presents a more difficult problem. All crude oils have a certain proportion of water intimately mixed with them, and as the specific gravity of most fuel oils is from ·9 to ·98, and in the case of some shale oils even higher, it is obviously exceedingly difficult to eliminate this water by gravitation unless the temperature of the mixture is comparatively high. The expansion of oil under increase of temperature is considerably greater than that of water, and some arrangement whereby heat can be applied to the contents of the bunker seems to be necessary where crude oil is used.

In furnaces where the oil fuel is burned in the form of vapour, the danger of extinction from the fact that water is present is of course considerably reduced, for any temperature that is sufficiently high to vaporize a fuel is more than sufficiently high to evaporate water, so that when water passes into the apparatus with the oil it flashes into steam, and though it breaks up the stream of hydrocarbon vapour does not prevent each fraction from burning unless the amount of water is abnormally large.

An experiment made by the writer showed that the fire was not extinguished when water was present in the proportion of five parts of water to three of oil. The water in that case was added gradually and the contents of the bunker were constantly stirred so as to secure as complete an admixture of the oil and water as possible.

With a burning apparatus of the second type where the oil fuel is introduced in the form of spray, the danger of extinguishing the fire when water is present is of course much greater, but with a well-designed installation and proper care on the part of the attendants such accidents as fires should be impossible.

The writer hopes that he has to some extent succeeded in laying before the Institution a brief review of the characteristics of liquid fuel and the various kinds of apparatus used for burning it The subject is one with which there are many members in this Institution better qualified to deal than is the present writer; these gentlemen will, he

hopes, contribute some of their valuable experiences with liquid fuel, which will serve to make good to some extent the imperfections of the paper.

DISCUSSION.

Mr. R. TRAILL said he had taken very great interest in the subject of the paper. With regard to the various methods of burning liquid fuel, he said Mr. Orde had understated the results obtained in burning oil fuel by the better-known methods, such as spraying it by means of steam, also by injecting it into furnaces in a pure state under pressure with a spraying burner without the assistance of steam or air. As the results of exhaustive experiments carried out by the firm with which he (Mr. Traill) was connected, it was clearly demonstrated that it was not necessary, as stated in the paper, to line the furnace with fire-bricks and to have large furnace space. They had been able to retain the ordinary furnace arrangement with the bars in position as required for coal burning and to burn oil by means of either the usual steam burner or the spray burner before mentioned and to get perfect combustion in a small space : the results they had obtained by these methods of burning with the introduction of the furnace bars, covered with broken fire-brick, was something like 14 to 15 lbs. of water evaporated per pound of fuel from and at 212 degrees.

They had been using the ordinary steam burner for the last ten years in steamers for the Caspian Sea, and latterly in large ocean-going steamers trading between this country and the far Eastern ports. Until quite recently oil was burnt in the furnaces with all the coal burning gear removed, but in more recent practice the furnace gear is retained, the firebars being well covered with broken fire-brick ; in this way they had been able to burn sufficient oil and to obtain as much power from the boilers as would be obtained in the ordinary way by a coal fire burning best coal, and he thought that was all that was necessary. By keeping the firebars in the furnace the efficiency had been very much increased. The type of burner known as the dry spray burner, and previously referred to, was coming rapidly to the front, especially in merchant steamers.

It was undesirable to use a steam burner, because the steam used in spraying the oil was lost and had to be made up by evaporators. The dry spray burner did away with the use of steam, which could not be returned to the condenser.

Further on, Mr. Orde mentioned that "the vapor thus produced can be completely oxidised by the amount of air chemically necessary and a larger quantity of oil can therefore be treated in the same furnace space than by either of the two other systems."

He (Mr. Traill) did not think that was correct, because without the firebars in the furnace a very much greater quantity of oil could be burned and a greater power obtained with an ordinary steam burner but not so efficiently. In Mr. Orde's system, steam is used in spraying, he (Mr. Traill) thought it was better to do away with steam altogether in order not to increase the evaporating plant, which was always an objectionable feature.

Coming to the advantages of using liquid fuel, and the methods of carrying it, Mr. Orde stated that with oil fuel having a flash point of 200 degrees, there should be no risk of explosion whatever. Lloyds drew the line at 200 degrees so far as their classification was concerned. A very important question in connection with oil fuel arose from the difficulty of getting rid of the water which was often intimately mixed with the oil. Most oils contain a small quantity of water so intimately mixed that it cannot be easily separated except by keeping the oil standing for a very long period or heating it to a very high temperature. The reduction in evaporative efficiency of oil so mixed with water was so small that it could be neglected entirely. But, again, there was also in many cases a large quantity of water mixed with the oil which could easily be separated. To get rid of this water an arrangement known as the Flannery-Boyd (patent) system, whereby the water is separated effectually, overcomes the difficulty.

Mr. Orde claimed for his method of oil burning, that he could burn oil containing a very large proportion of water, but it would certainly be an objectionable feature if oil on board ship had so much water as to interfere with the evaporative efficiency and thus reduce the power obtainable from the boilers with consequent reduction in speed ; it therefore became necessary to have the water separated in order to give the best results.

Another feature in regard to the separation of water arose from a method of carrying the fuel, and which led to the Flannery-Boyd system being invented. To fit old vessels, particularly, for carrying it, meant a very large alteration in the bunkers, and to reconstruct them would be a matter of very serious expense. Now, this difficulty was overcome by carrying the oil alternately with water ballast in the double bottom tanks, and in other spaces generally used in steamers for water ballast, and in the case of oil steamers also in the cofferdams, which spaces are

already oil-tight. But the great objection to the carrying of the oil in the ballast tanks was that water ballast could not be removed entirely from the tanks, this remaining water, when oil fuel was put into the tanks, became mixed with the oil, and in order to get rid of it it was passed through the Flannery-Boyd separators on its way to the furnaces.

Lloyds had dealt with the matter, and practically now any ordinary steamer could be readily fitted, at comparatively small cost, to carry oil fuel in the ballast tanks, thus obviating any structural alterations. The great obstacle to the adoption of liquid fuel, viz., the cost of providing suitable spaces for its accommodation, was therefore overcome by this system. He had just read an interesting account in the papers showing that the use of oil fuel on board ocean-going vessels was now far beyond the experimental stage, and also showing the great reduction in stokehold labour.

A vessel belonging to the Shell Line (M. Samuel & Co.) had just completed a 10,000 mile voyage burning entirely oil fuel, the number of firemen being reduced from twenty to ten. The vessel discharged the whole of her cargo, over 5,000 tons of oil, in London with her donkey boiler using oil fuel, the only coal on board the vessel being that required for the galley.

Mr. M. C. JAMES, in response to the President's invitation to speak, said he had not had any experience in oil burners, and so could not say anything authoritatively about them, but he was sorry to see the writer of the paper had, so to speak, jumped over several points which he (Mr. James) thought of very great interest and importance from a ship-owner's point of view, and worthy of very serious consideration. Mr. Orde claimed, for instance, as one of the advantages of liquid fuel, that there was a reduced temperature in the stokehold as compared with coal. He should like reliable data to support that contention, as he understood that with some forms of burners the reverse was really the case. Further, the writer maintained that there was increased life of boilers on account of constant temperature. It seemed rather premature to put in such a claim whilst oil fuel was as yet on its trial, and he failed to see how such a claim could so far be made with any confidence, and he would like some definite facts put forward to support it.

The PRESIDENT said they had a distinguished Russian engineer present that night, Professor Dvorkovitz, from Moscow, who had had considerable experience with liquid fuel in Russia, where it was used to

a greater extent than anywhere else. He asked him to favour them with a few remarks upon the paper.

Dr. DVORKOVITZ thanked the meeting for their kind permission to say a few words regarding liquid fuel. He remembered the time, about twenty-two years ago, when he was first invited to go from Moscow to take charge of a refinery at Baku. At that time they used very little liquid fuel, indeed, they did not know how to use it. Russian petroleum contained about 65 per cent. of residuals. They took off only 35 per cent. for burning oils, and had 65 per cent. left. Not knowing how to use it they had had to devise some means so as to burn the waste, and the most expert engineers and chemists had been engaged for that purpose. Since then things had changed in Russia. Mr. Nobel, of dynamite fame, had invented a furnace for the mechanical combustion of liquid fuel. It was a simple combination of plates, and great efficiency had been secured. There was an absolutely smokeless flame, but such apparata could only be used in stationary furnaces, and could not be used for locomotives or steamers. Now, the Caucasian Railway, opened in 1882, used nothing else but liquid fuel. For locomotives the liquid fuel was sprayed by means of air, and, as Mr. Orde had told them, the space provided was found to be too small in locomotive furnaces. After long trials they came to the conclusion that steam was the best means for spraying the fuel. In Russia the railways were now using 40 per cent. of oil for fuel, 35 per cent. coal, and the rest wood. In Russia the question of the economy of steam and cost of vaporizing did not occur, but in introducing the liquid fuel in Europe, the question of using steam was very important. In his opinion those who are working in the direction indicated by Mr. Orde are right. With superheated steam and superheated oil they must obtain better results than those who used wet steam. In fact, the superheating of the oil and steam is done by the waste gas, and this is very economical. Therefore he quite disagreed with the previous speaker who had said that steam itself gave a better result. The designer of an apparatus for liquid fuel, especially on steamers, had to be guided by the principle of economising waste heat, and if he superheated the steam he got a better result. There had been a question asked with regard to the life of the boilers. He did not suppose Mr. Orde was able to give a reply to the gentleman who asked the question; but having had many years' experience and observation at Baku and Moscow, where they used both oil and coal, he might state as a fact, which was supported by statistics published by the Russian Government, that the life of the boiler was considerably

longer when using liquid fuel than when using coal. It was obvious, because with liquid fuel a constant temperature was maintained. He really had come to speak not so much of the types of furnaces as with respect to the question whether the supply of oil was sufficient to warrant a large adoption of liquid fuel for steamers. Well, up to lately, the chief sources of supply had been America and Russia. America had not supplied, and did not supply, any oil for fuel. All the oil produced in America was used for manufacturing benzine, illuminating and lubricating oils. There were absolutely no residuals left to be used as fuel, so they must look elsewhere than to America for supplies. In Russia, the whole of the liquid fuel produced is required by Russia itself. The great extension of railways and the large development of manufactures, with the absence of coal in these districts, could only be supplied and maintained with liquid fuel. Therefore, those who were thinking of using liquid fuel must look to some other country. Within the last two or three years new oil fields were being opened up that could supply it. Roumania had lately begun to produce petroleum, and was yielding from two to three hundred thousand tons every year. The country was small, did not require the yield for itself, and therefore could supply it. Another country which had only lately developed oil fields (and they extended over 1,500 square miles) was Borneo. Every well put down there had proved very productive. The oil was most fit for fuel, and they were bound to sell a considerable proportion for fuel only. It contained about 25 to 30 per cent. of burning oil only, and the remainder could be sold for fuel. The next to Borneo were the Japanese wells, which would be found to be very rich. Having these fields at command, he thought a great many steamers in the Eastern trade would be able to rely upon a constant supply of liquid fuel. Dr. Dvorkovitz then produced a globular map of the world to show the members the various countries in which petroleum was found, and pointed out that these prolific oil fields were all found within a belt of from 36 degrees to 42 degrees. He came to the conclusion from this that the oil wells formed a ring round the world. If they followed on his map they would find that the oil fields are distributed on the ranges of the Carpathian, Caucasian, Himalayan, and Apscheron mountains. This led them to the inquiry, Where did the oil come from? A great many theories had been expressed, that it came from the centre of the earth where iron or metal carbides were in a molten state, and as soon as those carbides came in contact with petroleum hydrocarbons are found. There were other theories, but in following out investigations for ten years, from the peat-bogs in

Ireland to the coal deposits in England and Europe, he had come to the conclusion that petroleum was really a product of the distillation of coal. The chemical constitution of petroleum generally represented about 85 per cent. of carbon, and, roughly speaking, 15 per cent. of hydrogen. The chemical constitution of coal represented, roughly speaking, about 85 per cent. of carbon, about 5 per cent. of hydrogen, and about 10 per cent. of oxygen. There is, however, another description of coal which is poorer in hydrocarbons, namely, anthracite. On destructive distillation it was found to contain about 50 per cent. less of volatile matter than other classes of coal. Naturally, the question that arose in his mind was where they had gone, and his conclusion was that anthracite was a secondary formation of coal. The raising of the temperature in the upheaval of the Ural Mountains had played upon its coal measures and by the action of heat hydrocarbons had been distilled, flowing into the caves and hollows of the earth left by the upheaval of the mountains. If they looked at his map they would find the whole northern part of Europe, up to 32 degrees, seamed with coal, and near the mountains the oil deposits sloping towards the sea. As to the quantities, the Appalachian coal fields from which last year 60,000,000 tons of anthracite coal were raised. Now, the hydrocarbons eliminated from this quantity of coal represents from six to eight million tons of oil. The natural result of all this was that if petroleum was really a product of coal, the question occurred whether they had not in England enormous deposits of oil in the form of coal. The experiments he (Dr. Dvorkovitz) had made a few years ago showed that they had in Newcastle coal from which, if they imitated nature and exposed it to a low temperature and high pressure, 16 to 18 per cent. of petroleum hydrocarbons could be obtained.

The PRESIDENT said they were very pleased indeed to have Prof. Dvorkovitz with them that evening. They did not profess to know all about petroleum in England, but they thanked him cordially for his experience and information.

The meeting then adjourned, it being agreed to add the following communication to the discussion :—

102, FENCHURCH STREET,
LONDON, E.C.,
15th November, 1900.

DEAR MR. DUCKITT,

I received the copy of Mr. Orde's paper and have read the same with very great interest. The subject of liquid fuel is one in which I have

taken a considerable amount of interest for some time past, and our firm, I may add, is also interested in it from a business point of view. I think it is rather a pity that Mr. Orde, in his paper, has not given fuller details of the experiments which he has conducted, since a great deal of what he has not said must of necessity be imagined before one can say anything about them.

There are, however, one or two points upon which I should like to make a few remarks. Mr. Orde states that the solution of the question of oil fuel lies, first, in the cost of the fuel. No doubt Mr. Orde is to a great extent right on this point, but as in the case of all other products, the price must necessarily be governed by the market which it commands. At present, in this country, the demand is a very small one, compared with what is to be hoped it ultimately will become. Until that time occurs, however, the price is bound to remain at rather a high point. In my opinion, one of the most important considerations likely to affect the extensive adoption of oil fuel on ocean-going steamers, is not so much, at present at any rate, the price of the fuel itself as the cost of providing suitable space to carry it in. The case of oil-carrying vessels is rather different to that of steamers designed for ordinary trading—I mean tramps. In the first case the whole vessel maintains its expensive style of construction throughout, and the bunkers make very little difference. In the case of a tramp, however, not only would the bunkers have to be specially designed to be able to carry oil fuel, but the transverse bulkhead at the back of the boilers, in the event of a cross bunker, would have to be made oil-tight in scantling and riveting; and to make a cross bunker there would require to be an additional permanent transverse oil-tight bulkhead, and permanent centre bulkhead, which would also be practically oil-tight. The cost of all this work, to begin with, would be of such a nature as to terrify shipowners and prevent them from even considering the desirability of adopting oil fuel. Again, with regard to the oft-mentioned suggestion that the oil fuel might be carried in a double bottom. Apart from any consideration with regard to the use of the double bottom for water ballast, as well as for carrying oil, it must not be forgotten that a water ballast tank is not the same thing as a tank for carrying oil. Roughly speaking, to make a double bottom fit to carry liquid fuel in large quantities, would entail a cost of upwards of £2,000, and it is probable the whole of the bunkers required could not be carried in that part of the ship; this is assuming a vessel of say, 6,000 tons D.W. capacity. It is just possible that there might be some difficulty in convincing shipowners that they

would be likely to save sufficient, in the use of oil fuel, to compensate for this additional heavy expense in the first cost of their ships.

It would have been very interesting if Mr. Orde could have given some comparative figures as to the calorific value of the crude Borneo oil and one or two of the other liquid fuels. It seems to me that 18831 B.T.U. is rather a low figure and that other oils are better. The author of the paper includes "the advantage of liquid fuel giving increased life to the boilers, owing to the constant temperature." I have had some information given to me which leads me to conclude that this is not really so good as it sounds. It seems that actual practice at sea does not give the same results as are usually to be obtained in trials on shore. Engineers complain that the burners frequently go out without any warning. When this happens there is a consequent sudden low drop in the temperature of the furnace. Then the burners have to be relighted and the temperature suddenly goes up again. It is rather doubtful whether the result in such a case is not even worse than the effect on the furnaces caused by opening and shutting the doors for supplying them with coal when that fuel is used. This remark applies to those burners in which steam is used to pulverise the oil and in which cases the furnaces are not lined with bricks or other material likely to retain the intense heat until the burner has been relighted. Possibly the cause of the burner going out at sea is the presence of water which cannot be drained from the surface tanks so efficiently as in cases on shore, owing to the movement of the ship, which naturally stirs up the two and prevents them from separating. It almost seems to me that the best burner that can be adopted must be that with a purely mechanical spray, with which the furnaces would need to be lined with bricks or other material that would retain the heat and lower the temperature of the furnaces gradually after the burner has been extinguished.

I think the thanks of the members are due to Mr. Orde for the paper that he has put before us, and it should result in a very interesting and useful discussion. There is no doubt that liquid fuel has a great future before it, and that year by year it is more rapidly developing. In a subject like this there are many points open for discussion, but I think I have occupied your time quite long enough and must, therefore, leave the rest of the points connected with Mr. Orde's paper to some of the other members.

Yours faithfully,

H. E. J. CAMPS.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SEVENTEENTH SESSION, 1900-1901.

PROCEEDINGS.

ANNUAL DINNER IN NEWCASTLE.

The Annual Dinner in connection with the North-East Coast Institution of Engineers and Shipbuilders took place on Thursday, December 13th, 1900, in the Old Assembly Rooms, Westgate Road, Newcastle-upon-Tyne. Henry Withy, Esq., J.P. (President) occupied the chair, and Mr. J. R. Fothergill, the vice-chair. The guests of the Institution included the Mayor of Newcastle (Councillor John Beattie), the Right Rev. the Lord Bishop of Newcastle (Dr. Edgar Jacob), the Sheriff of Newcastle (Councillor J. J. Gillespie), Rev. Principal Gurney (Durham College of Science), Colonel Bingham (Sheffield), B. Plummer, Esq. (Chamber of Commerce), J. Nodder, Esq. (Messrs. John Brown & Co., Sheffield), J. Gravell, Esq. (Bureau Veritas), President of Institution of Cleveland Engineers (W. H. Panton, Esq.), President of Newcastle and District Association of Foremen Engineers (G. D. Weir, Esq.), H. E. Hollis, Esq. (Messrs. Seebohm & Dieckstahl, Sheffield), and the following Past-Presidents, Vice-Presidents, and Members of the Council of the Institution :—Past-Presidents — Wigham Richardson, Esq., Robert Thompson, Esq., Colonel H. F. Swan, and Sir B. C. Browne ; Vice-Presidents—J. R. Fothergill, Esq. (Chairman of Dinner Committee), Henry Fownes, Esq., W. H. Dugdale, Esq., J. M. Rennoldson, Esq., T. Westgarth, Esq., and Summers Hunter, Esq. ; Members of Council—A. G. Schaeffer, Esq., A. Harrison, Esq., W. G. S. Spence, Esq., M. C. James, Esq., R. Hirst, Esq. (Lloyds Register), D. R. MacDonald, Esq., J. H. Heck, Esq. (Lloyds Register), and John Duckitt, Esq. (Secretary). About 160 members and friends were present.

Letters of apology for inability to be present had been received from the Right Honourable Earl of Ravensworth, W. R. Plummer, Esq., M.P., Geo. Renwick, Esq., M.P., L. W. Adamson, Esq. (the High Sheriff of Northumberland), the President of the Institute of Naval Architects, and others. After an excellent dinner had been discussed,

The PRESIDENT proposed the health of "The Queen and Royal Family." In doing so he said he did not propose to dilate upon the virtues of the various members of the Royal Family. That they were popular, and that the people were loyal had been shown in a most marked manner lately, and he was sure it seemed to be a source of gratification to the Royal house as it was to them (the Engineers and Shipbuilders). The toast was appropriately honoured.

The MAYOR OF NEWCASTLE gave "The North-East Coast Institution of Engineers and Shipbuilders." In doing so he said he could not understand why he should have been called upon to propose the toast, except it was because he knew least about the Institution, and about the scientific, engineering, and shipbuilding capabilities of the gentlemen in the room. Since the Secretary had kindly asked him, however, to propose the toast he should do his best. In asking them to drink to the success of the Institution, he thought it was fit indeed that it should be drunk in the city of Newcastle. They had had many brilliant examples of engineering intellect and attainments in the city and on the northern rivers, whose fame had spread to the uttermost ends of the earth. He need not ask them to drink success to the Institution, because, so far as he could gather, their Institution had already succeeded. But he could ask them to drink to still further success. It was very pleasing to know that there was such a spirit of friendship among them, and that they were endeavouring to instruct the younger members of the profession in all the achievements and scientific discoveries that they had been making. No doubt all their efforts were required to keep abreast with the foreign nations of the world. As he learned from their Secretary, their Institution was commenced in 1884—that was about sixteen years ago—and he was glad to think that its numbers had attained to between 1,100 and 1,200. That must be a source of great strength to the Institution and a benefit to the members in their intercourse one with another. He could assure them it was a real pleasure to him that he should be asked to join them that night, and likewise to have made the friendships he had already made, and to

think that they had such eminent men at the head of their affairs. As representing the city of Newcastle it was very pleasant for him to be there, and he could only hope that their present prosperity would long continue, and that the benefits to the young and rising men of their profession would be continued with a greater success in the future than it had even been in the past.

The PRESIDENT, whose name had been associated with the toast, replied. He said he was sure they were all gratified by the kind interest the Mayor took in the Institution, and were exceedingly pleased to have had the honour of his presence there that night. As his Worship had said, the Institution had now a membership of between 1,100 and 1,200. Sixteen years ago they commenced, and they had gone on gradually, steadily increasing, not only in numbers but he thought in influence and in usefulness. Certainly the head office of the Institution was in Newcastle, but it had long ceased to be a local institution. They had members all over the country, members in foreign countries, even as far as Japan. There was a time when they were a small institution, and looked up with very great awe to the Institution of Naval Architects in London, and they also looked up to, as a great institution, the Institution of Engineers and Shipbuilders in Scotland. He was not a prophet, but he was disposed to think that if they went on at their present rate the other institutions would have to look up to them. The Institution of Naval Architects was a very ancient and honourable institution, and had always paid and still paid very great attention to naval matters, more especially in connection with the Admiralty. They built Admiralty ships in the district, but they paid more attention to the merchant navy, and he thought probably with rather better results than if they turned their attention to war ships. With regard to their success he believed it was a fact that they had a small balance in the bank—which was an exceedingly important point in those days. The Mayor was good enough to speak of the friendship and good feeling that existed between the various engineering and shipbuilding firms on the North-East coast. He (the President) wanted them to believe—in fact those who were members of the Institution knew full well—that that was very true. The friendship and freedom that existed between the firms on the coast was, he thought, quite extraordinary. He did not think any member of a firm on the Tyne would have the slightest difficulty in getting information which he wanted from any member of another firm in the districts

covered by the Institution. Personally he had never been refused any information that he had wanted on any subject, and he thought he could say he had never refused any information that brother ship-builders or engineers had asked him. He did not believe for a moment that they lost anything by giving information to others. He was sure they gained in a scientific way and probably in a monetary way as well. What they could do to raise the status of others raised their own status too. He would content himself with thanking the Mayor for the very kind way he had proposed the toast.

Sir BENJAMIN C. BROWNE, in proposing the toast of "Trade Progress and Technical Education," said they were always hearing that their trade was going to be killed by foreign competition. But it was not killed, because their trade lived upon their constant exertions to keep themselves from being passed by other people. Every now and again foreigners had tried to do better than they had done, and they tried to do better than the foreigners. Sometimes one got the better and sometimes the other. It was only by constant exertion that they kept up their position. From the time that England, instead of living by agriculture, began to live by manufacture and trade—from that time they were condemned to hard labour for life. In these days we had our little bits of scares about foreign trade. They knew how American ship-plates and German boiler-plates had come in and had concerned their friends, the steelmakers, a good bit. He remembered when his firm first started to make water-tube boilers they got the first machines from France. The next they got came from America, but now all they got came from England, because the English people had taken up all the best points and had made the best of all. A friend of theirs in Manchester had taken the trouble to study the machines and produced something better. As regarded the foreign houses, there was no doubt they had something to learn from them. The best foreign works in Europe and America were laid out marvellously well. They wanted to realise the importance of doing everything in the best and cheapest way, and it was better to buy from somebody else till they could afford to lay out their works as perfectly as possible. But to attain that it would be indispensable that within the reach of those with whom the future prosperity of the country rested there should be an efficient technical education, and it must be admitted that in that matter they had made a good deal of progress. When he first commenced to be an engineer, money could not buy the technical education which was now

within the reach of every hard working apprentice in Newcastle or any other large town. The young men of to-day, he wished also to say, were not slow to take advantage of this improved condition of things, and whether they had regard to the young apprentice or the young draughtsman they could find countless instances where they were doing their best to gain technical knowledge, and to do their work as well as it could be done, not merely for the sake of what they got for it but for the sake of the work itself. They wanted the young men to have a thoroughly sound education, so that they might know as much as possible. In Newcastle they had ample opportunities of acquiring technical knowledge, for their College of Physical Science was going to be one of the most important centres of English scientific education. He thought scientific education was best carried on in a scientific atmosphere, such, he believed, were to be found in their own College of Science, in Queen's College, Manchester, and similar places. They were absolutely essential to their success. They wanted to have the best possible men to carry out their work. The good old workman was a splendid man, but they didn't want a man to turn his hand to everything now. They wanted him to do one thing perfectly. With the toast he had the pleasure of coupling the name of Principal Gurney, who had come amongst them with an almost unique experience. He had got hold of the College and he certainly was bringing it on by strides, and what he was going to make of it before he was finished he (Sir Benjamin) could not say. He wished health to the trade of the district, he wished health to technical education, and above all health and long life to their friend Principal Gurney.

Principal GURNEY responded. He said one characteristic of the trade of that city which struck an observant outsider was its very great variety. Engineering and shipbuilding with all their allied industries, coal and coke, iron and steel, ropes, chains and timber, only formed a section of their local trade. They were in a very different position to a great many other towns that had a very restricted range. Newcastle occupied a more favoured position than perhaps any town in the kingdom with the exception of Glasgow. If one department of trade was a little dull another might be prosperous.

The toast suggested a connection between the progress of trade and technical education which had been more frequently recognised hitherto in other countries than our own. Technical education included all branches of learning, except what were called the dead languages; and one very important branch of it was commercial

education. What commercial education exactly ought to be he did not think at the present moment anybody was prepared to say. But there were a great many people who believed—and, he thought, with good reason—that if they were to devote more attention to commercial education they would materially advance the prospects of trade. Sometimes they had good trade and sometimes they had bad, and nobody knew exactly why. It was quite possible and quite conceivable that the solution of that and other similar questions might be materially helped by the scientific study of the laws which governed commerce. There were many industries which were very largely applied sciences. Of course in those cases it was very evident that one must know the science before it could be applied, and it was there that the work of technical education really started.

The term technical education had been much abused. It had sometimes been interpreted to mean evening classes in wood carving and sometimes in commercial arithmetic. The technical education that was needed in this country was a sound and solid knowledge of science, which could be given to a mind which had already been developed and cultivated by a generous and liberal education. There was no doubt that the Germans had found it well worth their while to spend in study at their technical colleges many of the years which our young men thought it was more profitable to spend in the works. The Germans also no doubt believed in the value of science as a factor in commercial success. They were not afraid to spend money in completing their technical education. He hoped Sir Benjamin Browne would not think he wished to predict the downfall of this country if he ventured to point out how seriously they were threatened by the action which had been going on for many years in Germany. Of course it would not be fair to ask a German to give them an account of the work that had been done in his own country, but an American gentleman addressing the American Institution of Electrical Engineers made the following statement :—He said : "The question we Americans have to ask ourselves is what have the Germans got for all the money they have spent on their education ? Formerly, scientific experts in the United States looked to England for exact standards, but now they go to Germany. Germany is rapidly moving towards industrial supremacy in Europe. Science has come to be regarded there as a commercial factor." If England is losing her supremacy in manufacture and commerce, as many claim, it is because of the English conservatism—not political—and the failure to utilise to the fullest extent the lessons taught by science. He (Principal Gurney) should like to believe that the advance of civilisation and the

progress of Christianity would cause the future conflicts between nations to be contests between intellect and not mere physical force. He should like to hope that instead of the men of the future doing all the harm to each other they could, that they would try to do the best work that they could, and if those views were perhaps too optimistic at present, they must remember that the commercial competition which was going on all over the world was not imaginary, but an actual fact in the age in which they lived. Commerce was more and more keenly contested every day, and the results of the competition became increasingly severe. Let them as patriotic Englishmen hope that their nation would pull herself together and maintain that position which she had held through so many ages in the past. We Englishmen would do well to lay to heart the lesson that had been taught us by that Institution of linking together trade progress and technical education.

Mr. ROBERT THOMPSON next proposed the health of "Our Guests," coupling with it the name of the Lord Bishop of Newcastle. He said he was quite sure they all joined with him in being pleased to see their guests that night. They had a most representative company. They had the Lord Bishop of Newcastle as representing the religious and moral training of the present generation; they had Principal Gurney representing technical education, and the Mayor of Newcastle representing law and order. He was sorry the Sheriff had had to leave them, but he represented form and decorum, and they had Colonel Bingham representing the military spirit. He was sure that they would all benefit by the remarks of those gentlemen that night. But after all work was one of the main things. They might have had a scientific education but unless there was a desire and disposition to work to the fullest extent that they could as human machines he was not quite sure that they should be able to hold their own. They had Mr. B. Plummer as their guest who represented general knowledge and a very near relative of his represented them in Parliament; they had also the President of the Cleveland engineers and the President of the foremen engineers. He was quite sure they all went to make up a complete whole, and he was sure with that amount of work which he had just indicated they should be able to hold their own in spite of all competition. They were pleased to have those gentlemen there that evening and he asked the company to drink to the health of the guests.

THE RIGHT REV. THE LORD BISHOP OF NEWCASTLE (Dr. Edgar Jacob), in responding, said he hoped that some day there would be

invented—he did not know if it was possible that such an invention could come through the North-East Coast Institution of Engineers and Shipbuilders—some sort of useful apparatus analogous to that of the Rontgen rays, by which a representative speaker might be able to look into the inner hearts of those whom he had to speak for, and to sum up in a few terse sentences the opinions which they might hold. He had to respond that night for the guests. He was thinking what it was that the guests, as a body, would like him to say on their behalf, and he confessed that his spirit sunk within him as he heard Mr. Robert Thompson say the various things which those guests represented. He heard that he (the Bishop) represented the moral and religious training. He thought that was a good deal to answer for. But as he went on further he found that he was to speak for law and order, as represented by His Worship the Mayor. He found further on that he had to respond for technical education as represented by his old friend Principal Gurney. About thirty years ago he made the acquaintance of Principal Gurney and that friendship had gone on ever since. He (the Bishop) confessed he never thought in those days that he should have to answer for technical education as well as other things. His spirit sunk still lower when he found he would have to answer for military ardour and military education as well as for all those other things. He did not know whether they noticed at a particular moment in Mr. Robert Thompson's speech he paused for a moment, and then his (the Bishop's) spirit sunk to zero when he found he had to answer for general knowledge. After that he must confess that he thought not even the North-East Coast Institution of Engineers and Shipbuilders could invent an apparatus so wonderful and so skilful as to be able to forecast what all those various gentlemen representing all those departments, including general knowledge, would have their representative to say. He was therefore thrown on his own resources to-night. The first thing he should say on behalf of the guests was that they had enjoyed meeting them all that evening, and it had been a real pleasure to them (the guests) to meet those who represented such a very important Institution as that which had done them the honour of inviting them to-night. And perhaps he might add one thing more, and that was that having served the office of a prison chaplain he felt entirely in his element, that he was dining with gentlemen who were, in Sir Benjamin Browne's words, condemned to hard labour for life. Believe him there was respite even for a man condemned to penal servitude for life, and therefore he confessed that while he sym-

pathised with those to whom he was speaking, and who were so condemned, still he saw even for them a ray of light in the gloom in which they had to live. He said gloom, because he could not help saying, after the admirable speech of his friend Principal Gurney, that it did seem to him (the Bishop) that it was possible that the sort of impression that might remain on their minds after all their hard labour was that they might see written over their door "made in Germany." He only hoped that the labour and skill of the Institution would avert so great a catastrophe. He had looked to getting some light on those matters which had occupied the public mind, and he was glad to hear what Sir Benjamin Browne had told them. He (the Bishop) had been something of a traveller, and had visited the United States two or three times, together with other parts of the world, and occasionally he had heard it said that the English manufacturer was a little too obstinate; that he insisted on making his own article and thrusting it down the throat of the world, whereas the German was more in the habit of seeing what the world wanted, and suited his mechanism and all that he did to the wants of the world. He was perfectly inexperienced in those matters, and he thought there was very little doubt that they representing that great Institution of the North-East Coast would do their utmost that at least in the profession that they represented they would hold their own against the competition of the world. There were two things which made him glad to be there that night. The first was that they represented what he might call local patriotism. He did believe that while there was a national patriotism it was a very good thing to have a local patriotism. And secondly, he liked the idea of having an institution which combined the older and younger men. He liked the idea of having an institution in which the younger men could mix with the older ones, and learn what they had to teach them, and could gradually become fitted to take their place in the front rank one day when the front rank fell. They could not always be in the front rank, and what they wanted was to have a second line which was perfectly fitted to go to the front rank when the front rank fell, and the institution or profession, or whatever it might be, which kept all its real power in the front rank, and did not bring on those who were subordinate and younger, was really a most short-sighted institution or administration. It did not do credit to itself, and certainly in the time to come it would prove a very vast mistake. They in that Institution seemed to him to be doing all they could to avoid that mistake. It was hopeless for him to represent all the various depart-

ments of science and general knowledge which were represented there that night, yet, speaking just as a humble individual, he wished them all blessing, God speed and success in the work which they had undertaken in their Institution, and on behalf of the guests he wished to thank them heartily for the kindness with which they had received the toast.

COL. H. F. SWAN proposed the health of the Dinner Committee, which was responded to by the CHAIRMAN (Mr. J. R. Fothergill).

The remainder of the evening was spent in free and pleasant social intercourse.

DINNER COMMITTEE.

Mr. J. R. Fothergill (Chairman).
,, Robert Thompson.
,, Henry Fownes.
Mr. A. G. Schaeffer.
,, John Duckitt (Secretary).

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SEVENTEENTH SESSION, 1900–1901.

PROCEEDINGS.

THIRD GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, DECEMBER 14TH, 1900.

HENRY WITHY, ESQ., J.P., PRESIDENT IN THE CHAIR.

The Secretary read the minutes of the last General Meeting, held in Sunderland, on November 16th, 1900, which were approved by the members present, and signed by the President.

The ballot for new members having been taken, the President appointed Mr. D. Andrew and Mr. M. Watson to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Blaylock, Robert, Forge Manager, 10, Greenbank Crescent, Darlington.
Figari, Emanuel D., Ship Draughtsman, Westoe Crescent, South Shields.
Fitzgerald, Durham W., Shipbuilder, etc, Messrs. J. T. Eltringham & Co., Stone Quay, South Shields.
Heslop, Thomas, Supt. Engineer, 6. Eldon Place, Newcastle-upon-Tyne.
Hewison, Herbert, Ship Draughtsman, 9, Mainsforth Terrace West, Sunderland.
Ito, Kumezo, Engineer, Mitsu Bishi Dockyard, Nagaski, Japan.
Manning, Henry Lewis, Engineer, Sea View, Ryhope, Sunderland.
Maughan, Philip A., Ship Draughtsman, 8, Ashleigh Grove, West Jesmond, Newcastle-upon-Tyne.
McDonald, John, Engineer, 40, Westgate Road, Newcastle-upon-Tyne.
McRae, Thomas, Ship Draughtsman, 16, Western Hill, Sunderland.
Oliver, John Wm., Engineer, 31, Baring Street, South Shields.
Paget, John W., Engineer Draughtsman, Roker Villa, Park View, Heaton Newcastle-upon-Tyne.

Phayer, Robert P., Shipbuilder, 27, Edwards Road, Whitley Bay, Northumberland.
Skentelbery, Joseph W., Engineer, 7, Washington Terrace, North Shields.
Smith, E. J., Engineer, Haughton-le-Skerne, Darlington
Surtees, Charles, Ship Draughtsman, 4, Cardwell Street, Roker, Sunderland.
Williams, Thomas, Iron and Steel Manufacturer, Messrs. South Durham Steel and Iron Co., West Hartlepool.

ASSOCIATE.

McBeath, Harry C., Accountant, Stromness, Billingham, Stockton on-Tees.

GRADUATES.

Armstrong, Harold S., Engineer, 16, Burdon Terrace, Newcastle-upon-Tyne.
Beilby, Walter H., Electrical Engineer, 1, Kingsley Place, Heaton, Newcastle-upon-Tyne.
Bennett, George H., Engineer Draughtsman, 15, Osborne Terrace, Gateshead-on-Tyne.
Bowmer, Matthew N., Engineer Apprentice, 8, Tankerville Terrace, Jesmond, Newcastle-upon-Tyne.
Burr, Percy B., Engineer Apprentice, 23, Moor View, Newcastle-upon-Tyne
Morris, David, Ship Draughtsman, Haingwood Terrace, Bill Quay-on-Tyne.
Potts, John N., Engineer Apprentice, 10, Ashburton Crescent, Gosforth, Newcastle-upon-Tyne.
Taylor, Arthur T., Engineer Draughtsman, 26, Rye Hill, Newcastle-upon-Tyne.
Thornton, E. Fielding, Engineer Pupil, 5, Catherine Terrace, Gateshead-on-Tyne.

THE GRADUATE AWARDS.

The PRESIDENT intimated that the following prizes had been awarded by the Council for papers read before the Graduate Section during last Session :—The sum of £2 10s. to Mr. Talbot Duckitt for his paper on "Electric Motors." The sum of £2 10s. to Mr. J. S. Posgate for his paper on "The Resistance of Ships." The sum of £2 10s. to Mr. B. S. Varty for his paper on "The Transverse Stability of Ships."

The PRESIDENT thought they must congratulate themselves that the graduates were reading papers of considerable value.

The Discussion on Mr. E. L. Orde's paper on "Liquid Fuel" was resumed.

Mr. J. W. JENNINGS read a paper on "The Ventilation and Heating of Ships by a Forced Circulation of Warm Air."

RESUMED DISCUSSION ON MR. E. L. ORDE'S PAPER ON "LIQUID FUEL."

The discussion was resumed on Mr. E. L. Orde's paper on "Liquid Fuel."

Mr. F. W. JENNINGS said there was one point in Mr. Orde's able paper which he thought might advantageously be further discussed, *i.e.*, the amount of air required for combustion. Mr. Orde stated that "the quantity of air required to complete combustion was very largely in excess of what was chemically necessary." This was very vague, and as all excess of air meant a loss in efficiency, due to the heat wasted in heating it, it was important that this excess should be as little as possible. Excess of air was mainly required because the fuel and air were insufficiently mixed ; the more complete the mixture the less the amount of air required, and it appeared to him that it should be an easy matter to thoroughly mix the air with liquid fuel, owing to the fact that it was generally admitted to the furnace in the form of spray or vapour. Mr. Orde stated that the best results he had been able to find only gave a fuel efficiency of 64·6 per cent. This seemed very low, and he thought that if proper consideration were given to the point mentioned it would not be a difficult matter to increase it. With solid fuels, an efficient mechanical stoker, and a properly designed system of artificial draught, an efficiency of 75 to 80 per cent. was not uncommon. In a paper on "Experiments with Automatic Mechanical Stokers," by Mr. J. M. Whitham, published in the *Transactions of the American Society of Mechanical Engineers*, Vol. XVII., some remarkable results were given, one test giving a fuel efficiency of about 80 per cent. with the air supply 11 per cent. *less* than that chemically required It therefore appeared to him that if an efficient system of artificial draught could be adopted in which the air supply was properly distributed and so arranged that it could be carefully graduated, much better results might be obtained.

Mr. WIGHAM RICHARDSON said he would like to ask a question of Mr. Orde. He had not been able to attend the meeting at Sunderland ; but he had read the paper carefully and with very great interest. It seemed to him of greater importance than, perhaps, appeared at first sight ; because, with the increasing cost of coal and the very large

deposits of petroleum that were being found, it was quite possible that in the future petroleum might play a much more important role in the propulsion of ships than it did at present. But what struck him who knew nothing whatever about it, or very little, was the most essential question, whether or not the steam jet could be entirely dispensed with? He had an idea that Mr. Orde knew about it, and would answer the question easily and, no doubt, satisfactorily, and he would be the first to admit that on the face of it it would seem to be a very great advantage if the spraying of petroleum could be effected by a jet of air without an admixture of steam, and still better if the air could be heated.

The SECRETARY read the following communication on the paper :—

12, CLYDEVIEW, PARTICK, GLASGOW,
November 26th, 1900.

DEAR MR. DUCKITT,

No one who has had any experience, even of the most elementary kind, with liquid fuel can have any doubt whatever as to its great advantages over coal. As pointed out in Mr. Orde's very interesting paper, these advantages can be summed up in very few words, viz. :— economy all round. The fact that its use conduces to the life of a boiler should alone recommend it, for it can be burnt in any boiler for any length of time without there being any necessity for allowing cold air to enter the furnaces as with coal burning. Any system that will do away with the strains resulting from the constant changes of temperature is to be commended. With oil fuel steam can be raised very quickly and with far less risk to the boiler.

The first type of burner mentioned by Mr. Orde is, as he says, noiseless, but that is about all that can be said for it. I have seen an apparatus at work that was specially designed for spraying the oil into the furnace ; it worked very well as long as the burner did not choke, but when this happened the oil was sent flying all over the place owing to the packing of the pump glands giving out.

Without doubt the best form of burner is the second one mentioned. It can be easily cleaned, and it is just as easy to control. When trying a burner of this class some years ago I found that by putting vanes in the air passage, which was concentric with that for the oil, a better admixture of the air and spray was obtained, and at the same time a sort of rolling motion was given to the flame which appeared to be beneficial.

The supply of air necessary is, as Mr. Orde says, much above what is chemically required, in fact anyone experimenting with oil fuel for the first time would get a great surprise, even after providing for a supply in excess of that required for the burning of coal in the same furnace.

I tried heated air as a spraying agent and found that the flame did not so readily become extinguished as with steam if the oil passage happened to get clogged. I may mention that the air was heated by passing the pipe leading it to the burner two or three times through the smoke box.

There should be no difficulty in producing sufficient compressed air, on board even the ordinary cargo boat, to drive the required number of jets without sacrificing any more steam than would be used by spraying with it direct.

Oil fuel has got a bad name owing to some accidents happening when it was first tried ; and the change from coal to oil is such a radical one that people think it means a tremendous outlay. In a sense the initial outlay would be large, but it would not be in connection with the apparatus necessary, only in connection with the depots which would have to be placed where the coal depots are now. I have heard some people say that as soon as oil fuel is a success up goes the price of both oil and oil refuse. This is a fact as I have experienced it.

I hope Mr. Orde's paper will meet with a good reception and that there will be an interesting discussion.

Yours faithfully,

A. E. SHUTE.

THE VENTILATING AND HEATING OF SHIPS BY A FORCED CIRCULATION OF WARM AIR.

By F. W. JENNINGS.

[Read before the Institution, in Newcastle-upon-Tyne, on December 14th, 1900.]

The usual introduction to a paper on ventilation is a harrowing description of the evils of bad ventilation, but this is scarcely necessary in a paper on ship ventilation read before an Institution consisting mainly of marine engineers and shipbuilders.

Ventilation and its close ally heating, although a most important subject, had in the past not received its fair share of attention, either in the case of buildings or ships. It is, perhaps, scarcely correct to use the word "attention." The subject has had, if anything, too much attention, but of the wrong people. The doctor, the clergyman, and the schoolmaster have had a lot to say, the architect and the inventor have had a lot to do, but there was very little improvement until it was put into the hands of the engineer. It is now, however, gradually becoming recognised that the subject of ventilation is worthy of special study, and that if efficient ventilation is required, those who have made a special study of it must be consulted. The fact that papers on ventilation have been read before the Institution of Civil Engineers and the Society of Arts within the past year, is a very good sign and shows that the right people are at last devoting attention to the subject.

Ventilation must be either natural or artificial, and after a somewhat careful study of the best known systems of natural ventilation, the writer has come to the conclusion that it is impossible to get positive and efficient ventilation, suitable for all climates, such as that required for ships, by any natural system.

Artificial or mechanical ventilation becomes at once divided into the *vacuum* and *plenum* systems. The balance of opinion a few years ago appeared to be in favour of the vacuum system, but with the improve-

ment of the plenum system it has fallen into disfavour, and the majority of recent writers on the subject have condemned it uncompromisingly and advocated the plenum system.

The great disadvantage of the vacuum system is that the entering air cannot be purified or warmed, and under certain conditions it is quite possible to replace the air extracted by other air just as foul ; it also tends to create draughts and is very liable to admit the entering air at the wrong place.

The writer has therefore decided to describe the plenum system only. The most common application is that in which the air is heated by being drawn or blown over steam coils and distributed to the various parts of the building or ship by means of a fan through brick flues, or galvanised iron piping. There is, however, a great variation in the methods of distribution, and each case should be considered on its merits. In a large, high building, such as a one-storey engineering works, in which the volume is great in proportion to the number of persons employed, ventilation becomes secondary to heating, as it is probable that if sufficient warm air is blown in to effectively heat the building, there will be sufficient for ventilation. On the other hand, if a passenger ship is being ventilated in which the volume is very small compared to the number of persons to be supplied with fresh air, ventilation at once becomes of paramount importance. The amount of fresh air supplied per human being should never be less than one cubic meter of air per minute, and should, if possible, be considerably more. Thirty cubic feet per minute, or slightly less than this, is the minimum allowed by law in several of the United States.

It will probably be found, in the case of the ordinary passenger ships, that to give efficient ventilation in the berths, the air will have to be changed from ten to fifteen times per hour, in the saloons and large spaces less, and in the crew's quarters rather more. To distribute this air effectively, and without creating a draught, is an exceedingly difficult problem, and one requiring very careful consideration. A ship presents several difficulties which do not occur in the case of buildings, the chief one being that it must be ventilated from the top, whereas, in the case of buildings, the fresh air can be admitted at one side, and the vitiated air allowed to escape at the other.

In ventilating large passenger steamers, the best results have been obtained by blowing fresh air into the passages, each passage forming a plenum chamber, and allowing it to pass into the cabins through louvres in the lower panels of the doors. After entering the cabin, the

temperature of the incoming air rises, and the vitiated air is extracted from the top by means of exhausting fans. In any cabins, state rooms or saloons which are not likely to be sufficiently crowded to increase the temperature, the warm air should be admitted at the top, and the vitiated air extracted from the bottom. Practical experience alone can tell where the dividing line comes between these two methods of distribution. It is advisable, wherever possible, to blow the air in the direction of the outer walls of the ship.

The writer has arranged a ventilating plant of this description for a large passenger ship, formed roughly on the lines of the "Kaiser Wilhelm Der Grosse." This is shown in Figs. 1 to 10, Plates I. to IV. In this ship there are 17 water-tight athwartship bulkheads, 15 extending to the upper deck, and 2 to the lower deck only. The piping has been arranged to miss these bulkheads, and thus avoid the necessity of water-tight gates. As a basis of calculation for deciding the size of the apparatus, it was assumed that it was necessary to maintain a temperature of + 15°C. (60°F.) throughout the ship, with a minimum outside temperature of — 10°C. (14°F.) On this basis the total heat loss was found to be about 720,000 calories per hour (2,880,000 British thermal units). To maintain the necessary inside temperature with the minimum outside temperature and allow a mean of 10 changes per hour for ventilation, it would be necessary to admit about 120,000 cubic metres (4,240,000 cubic feet) of air per hour, this air being heated to a temperature of 45°C. (113°F.) The engine-room, stokehold and hold are not included in this system, and will be mentioned later. Four combined fans and heaters are arranged as shown, each fan having approximately the same amount of work to do. To deliver the necessary volume at a pressure of about 4·5 centimetres (1·8 inches) of water, each fan would require to have a wheel about 5 feet in diameter, and would absorb about 9·6 brake horse-power. It is more economical to drive these fans by steam engines than by electric motors, as the exhaust steam from the fan engine can be used in part of the heaters. Assuming that this is done, and that the live steam is supplied to the remainder of the heater at a pressure of about 8 atmospheres (120 lbs. per square inch), the total amount of heating surface required in the steam coils for each apparatus would be about 60 square metres (650 square feet), and the maximum steam consumption for each apparatus, including that passing through the engine, would be about 830 kilos. (1,820 lbs.) per hour.

The fans could, if preferred, be driven by electric motors, and the

whole of the heater supplied with live steam, in which case the heater would be rather smaller, but the steam consumption would remain about the same.

The exhausting fans for extracting the foul air from the cabins should be of smaller capacity than the blowing fans, to enable a slight internal pressure to be always maintained. Allowing an exhausting fan for each blowing fan, they would require to have wheels 4 feet 6 inches in diameter, and would absorb about 6 brake horse-power each. It would probably be more economical to drive these fans by electric motors. In the plates the blowing fans and piping are shown in full lines, and the exhausting fans in dotted lines.

The ventilation of the stokehold depends on the type of forced draught used: if the closed stokehold system is adopted, it is not necessary to put in a special ventilating fan; if ventilating fans are fitted the writer would recommend them being made sufficiently large to give about 20 changes per hour. To do this in the ship in question would require two fans, each having wheels 3 feet 6 inches diameter, and absorbing 4·4 brake horse-power each. For the engine-room a fan with a wheel 3 feet 6 inches diameter run at a speed sufficient to absorb about 3·5 brake horse-power would give about 15 changes per hour, which would probably be found sufficient. In both the stokehold and engine-room, the air should be delivered near the floor, and as the temperature increases, it would rise and pass away through special outlet shafts and cowls provided, no exhausting fans being necessary. It is scarcely necessary to say that no heaters are necessary for either the stokeholds or engine-room.

Except in stokeholds and engine-room, the air should be admitted or extracted through registers, these being so proportioned that the speed of air through them does not exceed 2·5 metres per second; with this speed through the register it is not probable that the air would come in contact with the person at a speed of more than one metre per second when it would scarcely be felt.

The heaters shown on the arrangement of the ship described are known as the blow-through type; a detail of a heater of this type, showing steam and drain connections, is given on Plate V., Fig. 11. Plate VI., Fig. 13, shows a blow-through heater fitted with a cold air bye-pass. With a heater of this description the temperature of the air delivered from the apparatus can be varied at leisure, by means of the mixing damper shown. A draw-through heater is shown on Plate V., Fig. 12. This is the simplest form of heater, and is attached to the

inlet of the fan, the air being drawn through, as implied by the name. Plate VI., Fig. 14, shows the type of heater necessary for what is known as the double duct, or hot and cold system: with this system it is possible, by means of mixing dampers, to vary the temperature in different parts of the ship; it has, however, the great disadvantage of entailing a double system of piping throughout, and consequently is very little used for ships, although very commonly used for large public buildings, schools, etc

In addition to the various methods mentioned of regulating the temperature, it is advisable to have the heaters made up of independent sections, each having a separate steam and drain connection; it is then an easy matter to shut off any section if the temperature is found to be too great. A detail of a section of this description is shown on Plate VII., Figs. 15 and 16.

Steam traps are required for each heater, and should be provided with a bye-pass. This bye-pass should be opened before the heater is started to work, and steam blown through to clear all air out of pipes. A suitable steam trap, with a bye-pass of this description, is shown on Plate VII., Figs. 17 and 18.

The American liners, "St. Louis" and "St. Paul," are ventilated and heated on the system described. Four separate plants are installed, each plant consisting of a blowing and exhausting apparatus, both located on the shade deck, and driven by direct-connected electric motors. From each of these apparatus pipes extend downwards, and upon each deck connect with horizontal systems, no pipes passing through the transverse bulkheads. The arrangement is indicated on Plate VIII., Figs. 19 and 20, showing a longitudinal section and plan of the shade deck, which embraces one of these systems. Smaller auxiliary fans, one shown on either side of the ship, supply fresh air to the engine-rooms, etc., while the large fan shown in elevation exhausts solely from the galley.

Exhausting fans are probably only necessary in the case of large passenger liners, such as those described. In war ships very good results have been obtained by blowing warm air direct into the cabins, etc., and allowing the vitiated air to pass into the passages, and find its way out through special outlets provided, thus reversing the previous method of distribution.

Several cruisers in the Dutch navy have been ventilated and heated in this manner, and proved very satisfactory. For the ventilation and heating of H.D.M.S. "Gelderland," two sets of apparatus were used,

each fan having a wheel 3 feet in diameter, and absorbing 4·1 brake horse-power. This ship is approximately equivalent to a British third class cruiser. H.D.M.S. "Zeehond" was ventilated and heated on the double duct system; an isometric view, showing how the pipes were arranged in this ship, is given on Plate IX., Fig. 21.

It is not always possible to avoid passing through the watertight bulkheads with the piping, in which case watertight gates have to be fitted, which should be automatic in their action.

Whilst the problem of ventilation is of most importance in the case of passenger and cattle ships, it should be borne in mind that different cargoes require proper ventilation, as for instance, oils, rice, coal, etc.

In the case of coals, a thorough system of surface ventilation is probably the best, which removes the gases given off by the coal lying in heaps. The difficulty with rice cargoes is the moisture and fermentation which is best carried off by the air as it forms, to prevent damage to cargo In oil tank steamers proper provision should be made for removing the explosive vapours.

The writer trusts that these notes, dealing with an important and intricate subject, in a somewhat inadequate manner, will yield a long and interesting discussion. The shipbuilding members of the Institution will probably consider the system of piping shown very intricate and difficult to work in, but it is not so bad as it appears on paper, as, if the pipes are made of galvanised iron, they can be almost any shape.

If the writer may presume to offer a little advice, it is that shipbuilders consult the ventilating engineers just as soon as they possibly can, that is to say, when they can give sufficient information to enable the heat losses and volumes to be taken out.

Several of the leading architects now work in consultation with the ventilating engineers from the commencement of their designs, although, unfortunately, there are still many to whom an air duct is an abomination, and the writer fails to see why naval architects should not do the same.

In conclusion, he must express his great indebtedness to the Sturtevant Engineering Co. for the assistance they have given him in the preparation of this paper.

DISCUSSION.

Mr. WIGHAM RICHARDSON said Mr. Jennings had mentioned the American steamships. He should be glad to know whether there had been any difficulty as regards the heating of these ships arising from

the fact that the American citizens, as far as he had observed, were never comfortable unless at a much higher temperature than Englishmen would? He thought English people were accustomed to sit in rooms with a temperature in the neighbourhood of 60 degrees Fahr. His experience in the States led him to infer that an American never was comfortable unless the room was heated at least 10 degrees higher, a temperature which to himself almost took away the pleasure of social meetings. On the other hand, he once met an American gentleman going back to the States, who said no person in the world could describe the agony and misery of travelling in the English cars with no heating apparatus! American gentlemen did not take special clothing because they trusted to every place being properly warmed. Another question was as to the vitiated atmosphere, whether warm or cold. Was the foul air lighter or heavier than the untainted air? If they talked to the ordinary man in the street he would tell them that the foul air always went to the top of the room, and he would tell you how he once had been hanging a picture near the ceiling and was nearly suffocated! Was it a fact or not that the vitiated air, that is, what they used to call "carbonic oxide"—he believed it had a new name now—was always the heavier? Was it not a fact, so far at least as English taste is concerned, that rooms with an open fire are always the most fresh and pleasant? And is not this probably due to the fact that the flue of an open fire is a most efficient exhauster? Is it not further to be noticed that this abstraction or exhausting of the air from the room takes the foul air away at a low level, say within 2 feet of the floor line, to where if it be the heaviest the foul air must necessarily gravitate? He had one other question. A difficulty he saw was this:—if he rightly understood the plenum system, it meant having a slightly greater density in the apartment than in the outer air; but he had travelled by sea, he might say, in all weathers and at all times, and he did not think people were very fond of locked doors. If they went across in one of the Atlantic liners, generally speaking, the wide staircase and the doors into the saloon were generally left wide open, and how was the increased pressure, therefore, maintained?

Mr. F. W. JENNINGS said that he could not say definitely whether the temperature in the American ships mentioned was maintained at 70 or 60 degrees, but it was probably the former, as 70 degrees was the standard for America, whereas 60 was the standard for England. It was, however, just as easy to maintain a temperature of 70 degrees as

60, it simply required a larger heater and consequently more steam. In fact there was practically no limit to the temperature which could be maintained with apparatus of the type described. Precisely the same type was often used for drying purposes, for which very high temperatures were sometimes required. *Re* the weight and temperature of the vitiated air, he might say that theoretically the vitiated air was heavier than the untainted air owing to the formation of carbonic acid gas which was about one and a half times heavier than air; but, practically, the carbonic acid gas was never formed without the temperature being increased, consequently the vitiated air did not fall but rose above the level of the breathing line. He (Mr Jennings) did not think that the English open fire assisted ventilation in the average room to any appreciable extent. It was an exceedingly costly way of heating a room, and it would be much more satisfactory and economical to blow warm air in. There was probably a certain amount of induced draught to the fire, but there was the same objection to this as to the vacuum system mentioned in the paper. They were obliged to have in the rooms what there was outside which might be just as foul as that going up the chimney.

He did not think that there would be any difficulty owing to doors, etc., being left open. If there was any objection on this account it would apply much more to engineering works than to ships, yet the system described had been largely adopted in works of this description and had given every satisfaction.

The PRESIDENT said, as Mr. Jennings would not be present at next meeting, he thought they might tender him their sincere thanks for his paper.

This was carried by acclamation, and the meeting adjourned.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SEVENTEENTH SESSION, 1900-1901.

PROCEEDINGS.

FOURTH GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, FEBRUARY 1ST, 1901.

HENRY WITHY, ESQ., J.P., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, held in Sunderland on December 14th, 1900, which were approved by the members present, and signed by the President.

The ballot for new members having been taken, the President appointed Mr. R. H. Muir and Mr. Chas. Dowsen to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Eltringham, Harry, Shipbuilder and Boilermaker, Messrs. J. T. Eltringham & Co., South Shields.

Ferguson, Wm. Deeble, Consulting Engineer, Iveagh Chambers, Belfast.

Head, William, Shipbuilder, 4, Grosvenor Place, North Shields.

Hunt, Allan E., Ship Surveyor, St. Cuthbert's Terrace, Bensham, Gateshead.

Jarvis, H. Robert, Engineer Draughtsman, 6, Dene View, Wallsend-on-Tyne.

Loveridge, Wm. Henry, Iron Merchant and Engineer, York Road, West Hartlepool.

Morgan, John Osborn, Consulting Engineer, Bank Chambers, Sandhill, Newcastle.

Nicholson, P. F., Shipbuilder, Messrs. Hawthorn, Leslie & Co., Hebburn-on-Tyne.

Terry, F. Herbert, Managing Director, Messrs. Tyne Brass and Copper Tube Manufacturing Co., Jarrow-on-Tyne.
Tobin, Thos. Charles, Ship Draughtsman, 16, Beech Grove Road, Newcastle.
Vowell, Josias, Engineer, Boys' Industrial School, Thomas Street, Sunderland.
White, A. F., Supt. Engineer, 2, Fenchurch Avenue, London, E.C.

GRADUATE TO MEMBER.

Mitchell, Wm., Ship Draughtsman, Glen Street, Hebburn-on-Tyne.

ASSOCIATES.

Thorpe, Samuel, Iron and Steel Merchant, 4, Alliance Buildings, George Street, Sheffield.
Ward, Heber, Accountant, Messrs. Walker & Hall, Sheffield.

GRADUATES.

Bertram, S. Norman, Engineer Draughtsman, 7, Lovaine Row, Tynemouth.
Cothay, Frank H., Engineer Apprentice, 38, The Avenue, Sunderland.
Dowsen, Junr., Charles, Ship Draughtsman, 21, Croft Terrace, Jarrow-on-Tyne.
Fitzgerald, Arthur F., Ship Draughtsman, 1, Wood Terrace, South Shields.
Fitzgerald, Junr., Durham Walker, Ship Draughtsman, 1, Wood Terrace, Westoe, South Shields.
Gibbons, Norman B., Engineer Pupil, 26, Hawthorn Street, Newcastle.

THE DEATH OF THE QUEEN.

The PRESIDENT said this was the first General Meeting they had had since the loss of our beloved Queen, and he was quite sure that no words of his were necessary to commend the resolution he proposed to move: but that they would all agree with him most heartily in tendering sympathy to the Royal Family, and in desiring that the King may live a long time. He begged to move that the following address be sent to the King:—

To His Most Excellent Majesty the King.

May it please Your Majesty,

We, the President, Council, Members, Associates, and Graduates of the North-East Coast Institution of Engineers and Shipbuilders, Newcastle upon Tyne, desire to express our heartfelt sympathy with Your Majesty, Queen Alexandra and the Members of the Royal Family, and our profound regret at the great loss which you, the Nation, and the Empire have sustained in the death of our late beloved Sovereign Queen Victoria; and to record our sincere feelings of loyalty and devotion to Your Majesty, humbly praying that Your Majesty may enjoy a happy and prosperous reign and be long spared to occupy the throne of your illustrious ancestors.

Witness our hands the First day of February, 1901

Henry Withy President.

John Duckitt Secretary.

Mr. G. E. MACARTHY said he would simply content himself by formally seconding the proposal. He thought it was unnecessary to comment upon it—it expressed all their views.

The resolution was adopted by the members standing, and the Secretary was instructed to forward the address to the proper quarter.

Mr. E. L. ORDE replied to the Discussion on his paper on "Liquid Fuel."

The Discussion on Mr. F. W. JENNINGS' paper on "The Ventilating and Heating of Ships" was resumed.

The SECRETARY read a paper by Mr. G. M. BROWN on "Some Attempts to Increase the Efficiency of Marine Boilers."

MR. E. L. ORDE'S REPLY TO THE DISCUSSION OF HIS PAPER ON "LIQUID FUEL."

Mr. E. L. ORDE said that before replying to the points raised by the various speakers on his paper, he must first thank the members of the Institution for the cordial way in which the paper had been received, and for the remarks that had fallen from several of them. Mr. Traill's remarks were of great interest, and in his objection to the using of the steam burner he was, of course, voicing the opinion of everyone who had ever considered the matter. It was, however, unfortunately, with steam only that the best results could be obtained, for the reasons which had been explained in the paper. With regard to the quantity of oil which could be burned in a given space, Mr. Traill had not, apparently, interpreted the statement in the paper in the way in which it was meant. The statement was, "the vapour thus produced can be completely oxidised by the amount of air chemically necessary, and a larger quantity of oil can, therefore, be treated in the same furnace space than by either of the two other systems." Now, it had been found by experiment, and had been confirmed by, he believed, everyone who had ever had practical experience of this subject, that, in burning oil as a spray, the amount of air required for combustion was very much larger than that which was chemically necessary. If, therefore, it was possible to produce a petroleum vapour which required no more than the amount of air chemically necessary, it was obviously possible to burn more of it in a given space, which was all that was advanced in the paper. It was, of course, true that if the firebars were removed a larger quantity of oil could be burned. It was very interesting to hear Mr. Traill's experience of separating water from oil, but he must confess that his own went to shew that it was not quite so simple a matter as it might appear, and that it was, above all things, important that it should be as completely carried out as possible.

In reply to Mr. James, the temperature in the stokehold, as observed on the trial trips of two steamers, immediately before the furnace front was 90 degs. in one case and 92 degs. in another, and in the hottest place which could be found in the stokehold (in this case the vessel had two boilers at the after end of the boiler room and one at the forward end, with a common funnel in between, and an up-take arched over the

centre part of the stokehold), the temperature was only 100 degs. As regards the increased life of the boilers, it must, of course, be understood that this only held good with good oil, and a well designed apparatus. Dr. Dvorkovitz had kindly given them the results of experience on this point in Russia, and he need only add that in his own experience several vessels which had been fitted up for liquid fuel for Russia had been satisfactory in this respect.

He must tender his thanks to Dr. Dvorkovitz for his contribution to the discussion, which was exceedingly interesting, and contained information such as no one but an expert chemist who had devoted a great part of his life to the petroleum formations could have given. If his theory as to its formation was right, they need apparently have little fear as to future supplies of petroleums which would be fit for fuel purposes.

Mr. Camps in his letter raised a point which in itself required a most ample discussion, and one which was too important to be dealt with in the short time available that night. This was the question as to how oil fuel could best be carried on board ships, other than tank steamers. Fortunately, fuel oil was in itself thick and viscous, and it was therefore not difficult to contain it, but its contact with steel removed any oxide scale instead of forming it so that it could not be relied on to make bad joints into good ones. The point was one which had not so far come sufficiently under the notice of practical shipbuilders to enable more than an approximate estimate of cost to be made, but he thought Mr. Camp's figures were above the mark. As regards the calorific value of crude Borneo oil, it corresponded closely with that of the oils of other countries. Various samples of oils of which the heat value had been measured by the calorimeter showed that from 18,000 to 20,000 B.T.U. was about the average.

The sudden extinction of burners to which Mr. Camps alluded must, of course, be expected as long as water was present in any quantity in the oil, but if proper attention was given to this there should be no fear of any extinction from this cause, and therefore the change of furnace temperature was not likely to be great. The great objection to lining the furnace with fire brick, as he suggested, was that the temperature in the combustion chamber was thereby raised very much above what was essential for the complete oxidation of the carbon monoxide, and therefore the final stage of combustion was apt to take place in the up-take and funnel.

Mr Jennings raised a point which was one of the most important in all the economy of combustion, that was the amount of air required to

complete it. The fuel efficiency which he gave as 64·6 per cent. related to the first class of burner, that in which the fuel was injected into the furnace as a spray by a purely mechanical means. With the system, which in his opinion promised to give the best results, the oil was wholly or partly vaporised, and the amount of air required for combustion had been reduced to almost the exact amount required. On a trial on one vessel the air used was 14·5 lbs. per lb. of oil, while the amount chemically necessary for combustion was slightly over 14·4. The fuel efficiency in this instance was nearly 81 per cent.

Probably the most satisfactory way of obtaining the highest efficiency from oil fuel was by burning it in a vaporous form in the presence of air admitted into the furnace by mechanical means and having this air heated by means of the waste gases. The economy of heat thus obtained ought to increase the evaporative power of the boiler by at least 1 lb. of water from and at 212, as compared with ordinary draft.

In reply to Mr. Wigham Richardson the advantage of using steam appeared to be that in the presence of super-heated steam the mean boiling point of the hydro carbon oil was lowered, and the fuel, therefore, passed into a vaporous form at a temperature below that necessary to decompose it and deposit fixed carbon.

Mr. Shute's letter was most interesting ; the type of burner which he said he had found to give the best results was much the best known, and had, in some cases, given excellent results. The writer, however, ventured to adhere to the opinion expressed in his paper that vapour burners would give the best results of all.

Since this paper was written, Admiral Melville, Chief of the Bureau of Naval Steam Engineering in the United States, has given his annual report as to the progress made in some experiments which he was carrying out with petroleum fuel.

The conclusion he came to was as follows : " So far, the success with the jet type of burner does not seem to indicate possible satisfaction. The best type of jet or spray burner yet used on the 'Talbot' has failed to secure power for a sustained speed of more than three-fourths the full trial speed of the boat even for half an hour, while the smoke feature is equally as evident as with soft coal, except at speeds as low as ten knots. Great convenience attaches itself to the use of oil fuel, especially in these small boats, owing to the instant control obtained thereby over the fires and the avoidance of handling ashes or cleaning fires while under way. In point of economy and full efficiency, however, it has not yet been demonstrated, either in this country or abroad, that

a change from coals is at present possible. The first desideratum in this field is to secure full power without smoke, the matter of economy in the torpedo boat class being of secondary consideration. By reason of this smoke question the difficulties are greater than they otherwise would be. Experiments with a retort burner, in which the oil is volatilised and mixed with hot air before issuing therefrom, are now in hand, and, while giving promise of a greater efficiency than did the jet apparatus, sufficiently definite results have not yet been obtained upon which to base positive conclusions. He (Admiral Melville) wished to note here that not one of the burners experimented with was of Bureau design. The great number and variety of oil burners extant, covering the results of the work of hundreds of inventors, has afforded opportunity for selecting types of ample variety, for its experiments, and securing also the advantage, in many cases, of the inventor's personal directions." The "Talbot" is a torpedo boat 100 feet by 12 feet with a draught of 3 feet 3 inches, an indicated horse-power of 850 and a speed of 20 knots. His (Admiral Melville's) opinion so closely coincided with that which he was led to form as a result of the experiments which he was connected with, that he could not conclude his reply more forcibly than by quoting it. The only sentence to which he ventured to take exception in the report was that in which it was stated that, in point of economy and fuel efficiency, it had not yet been demonstrated either in this country or abroad, that a change from coal was at present possible. This he ventured to think was being every day more clearly shewn not to be the case, at all events at ordinary rates of evaporation. He must now thank the President and gentlemen for the kind attention they had given to his remarks.

The PRESIDENT was sure they would all be desirous of showing their appreciation of Mr. Orde's paper, and he asked them to pass a vote of thanks in the ordinary way.

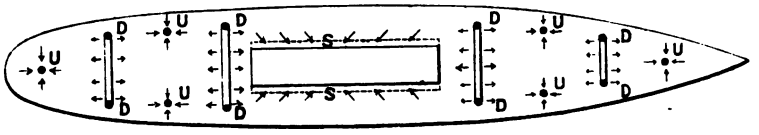
The vote was accorded by acclamation.

RESUMED DISCUSSION ON MR. F. W. JENNINGS' PAPER ON "THE VENTILATING AND HEATING OF SHIPS."

Mr. E. W. De Rusett, resuming the discussion on Mr. Jennings' paper, said he thought that they would all agree that the paper was a very useful one, and showed considerable knowledge of the subject. He thought, however, that it was rather hard upon naval architects when the author stated that "the right people are at last devoting attention to this subject"—referring to the Civil Engineers and Society of Arts—but he (Mr. De Rusett) had no hesitation in saying that the naval architects had advanced a good way towards solving the question long before these learned societies had seriously turned their attention to it. However, they were thankful for every help. With regard to the different systems of ventilation enumerated in the paper, he thought that the plenum, combined with the vacuum, was better than either separately, and much to be preferred to natural ventilation; and the writer appears to entertain the same view, although he advocates the plenum system only, as in page 75, he introduces vacuum fans for extracting vitiated air. The author stated that the amount of air to be provided per passenger should be at least thirty-five cubic feet per minute, and that it should be changed from ten to fifteen times per hour; but he (Mr. De Rusett) thought this was much in excess of the quantity required to be provided by artificial means in any ordinary passenger steamer, as the stairways and skylights, besides pipe ventilators and ventilating sidelights, would afford additional means of ventilation. This he would refer to more in detail presently.

Some fifteen years ago, when naval architect to the P. & O. Co., he (Mr. De Rusett) designed the mechanical ventilation for the passenger 'tween decks of two of that Company's large first class mail steamers, the "Oceana" and "Arcadia," on a combined plenum and vacuum system, and at the same time two corresponding vessels belonging to the same Company were ventilated on the vacuum system, but in each instance natural ventilation was rendered available. In the instance of the "Oceana" and "Arcadia," the plenum was obtained by inducing a draught by means of self-regulating annular nozzles worked by air compressed to about 4lbs. per inch. These nozzles were placed in the ordinary deck ventilating pipes, and the air was distributed through regulated holes in a series of rectangular trunks placed under the beams

about eighty feet apart, and extending nearly across the passenger accommodation. Between these trunks were upcast ventilating pipes in which were placed similar nozzles producing a vacuum, and discharging the vitiated air on deck as per sketch.



S.S. Skid Skylights abreast of Engine and Boiler Casings, forming upcast ventilators.
U.U. Upcast Ventilators, air induced by compressed air nozzles.
D.D. Downcast Ventilators and Air Ducts, air induced by compressed air nozzles.

This was found to work very well. The plan carried out in the two other vessels was not so effective, in which the air was extracted by a reciprocating vacuum pump placed in the engine room, to which it was conducted by two rectangular trunks running under the beams in a fore and aft direction, with regulated openings at frequent intervals. The air was admitted into the passages, etc., by cowl headed pipes from the deck. The fact is, the majority of passengers, especially in warm climates, like to feel the air playing gently upon them, and do not think they are getting sufficient unless this is the case. Of course air can be freely blown into a ship by cowl or other headed deck pipes, but then it cannot be readily regulated, and will not flow if there are acute angles or suddenly contracted passages, and these cannot be avoided when air ducts have to be worked in with passenger accommodation. He mentioned that, in the main dining saloon of the "Oceana" and "Arcadia," warm air was discharged by nozzles, after being first heated by passing over a series of steam pipes placed under the sofas.

As another instance Mr. De Rusett mentioned the "Invernia," a very large vessel built by his firm (Messrs. C. S. Swan & Hunter), for the Cunard Co., in which the combined plenum and vacuum system was adopted, aided by natural ventilation. This was applied to the 'tween deck passenger accommodation, holds and store rooms, with most satisfactory results. There were employed a number of large electrically driven fans, of which five were used to force air into the passenger accommodation; the ducts for each were led transversely with fore and aft branches, all having numerous regulated apertures, discharging air in every direction, but primarily into the passages, from whence it flowed into the cabins, etc. The air could be warmed in any compartment when desired, by passing it through thermotanks (steam heated cylindrical

vessels), or by reversing a valve the air could be extracted from any passenger compartment. The fore and aft pipes were all in union, or they could be disassociated by valves, as required, so that one fan could be forcing and another extracting. Air was changed by mechanical means alone about seven times in the hour, and this was assisted by natural ventilation through deck pipes having patent heads, besides Utley's automatic sidelights and air trunks supplied any extra required. The result, after eight voyages, was reported to be very satisfactory as regards sweetness and warmth, both of which were perfectly under control. There was also an absence of draught. He (Mr. De Rusett), mentioned these facts, not as a puff, but to emphasise the fact that naval architects were fully alive to the importance of this detail of their profession.

The following communications on the paper were ordered by the President to be printed in the *Transactions*.

Communication from Mr. W. MAXWELL STEWART, of Glasgow.

Mr. F. W. Jennings deserves great credit for having brought before the Institution the importance of a mechanical system of ventilation and air warming on board ship. The writer, having had considerable experience with many forms of ship's ventilation, quite agrees with the author that no natural system of ventilation can be fitted so as to meet the varying conditions of climate and weather in an efficient manner. The author states that the vacuum system has fallen into disfavour, owing to the improvements made on the plenum system, but the writer thinks that there are still many who prefer the vacuum to the plenum system.

A few years ago, the writer became associated with the development of an apparatus called the Ventilating Thermotank, designed and invented to fulfil the undermentioned conditions, viz :—

1st. To supply either warmed or cooled air.
2nd. To fulfil either plenum or vacuum conditions.
3rd. To circulate air.

A short description of this apparatus and its application may be of interest to the members of this Institution, as it is now being adopted and has already been fitted on board some of the principal first class passenger steamers and war ships built in this country.

Plate X. shows the arrangement and construction of the apparatus. It will be seen that it consists of the thermotank proper, or heater, which is a cylinder with tubes passing through it from end to end, enclosed in an outer casing, to which the discharge branch from the fan is connected.

The heating or cooling medium circulates in the cylinder round the tubes, through which the air to be heated or cooled passes on its way from the fan to the compartments. Special attention has been given to the efficiency of the thermotank by enclosing it in a casing, as shown, and allowing the entering air to pass over the outer surface first, ensuring in this way that the air does not meet any surface through which heat can be lost by radiation, after it has been heated to the desired temperature.

The apparatus has also been designed so as to give the greatest heating or cooling surfaces and to supply the largest possible volume of air in as small a space as working conditions will allow.

The great improvement of this system, as compared with the system of heating by steam pipes, will be seen from Plate XI., which shows the plotted results of comparative tests made by the officers of the Russian Volunteer Fleet on two steamers belonging to that fleet. From these curves it will be seen that, making allowance for the difference in volume of the compartments, the thermotank system in the "Kostroma" raised the temperature 5 degs. Fahr., in say seven and a half minutes, as against two hours required in the "Moskva" for the same rise of temperature. The steam supply pipe was the same size in both cases but whereas, in the ordinary pipe heating system, the stop valve was full open, in the case of the thermotank it was only one turn open, so that in addition to a greatly increased heating power, there is a large saving in the proportionate amount of steam consumed.

To meet the requirements of vessels which have to deal with warm, as well as cold climates, an arrangement is made by which cold brine or direct expanded gas is supplied to the thermotank from a refrigerating plant, and in this way the ingoing air may be cooled to any desired temperature.

The importance of a cold air supply can hardly be over rated for ships in hot climates, not only for the comfort of the living quarters, but also for the preservation of cargoes which require to be kept at low temperatures.

In order to show the working of the thermotank for supplying, circulating, or exhausting air, the different valves have been arranged and lettered A, B, C, D, E, F, respectively on Plate X. The mode of operation is as follows :—

1. *Heating or cooling fresh supply of Air.*—The valves A, C, and E are closed. The air then enters by the valve B and is driven by the fan through the tubes in the thermotank (which is either heated or cooled

as the case may be) into the trunks through the valve D. It is then distributed to the compartments by the louvres in the usual way.

2. *Exhausting Foul Air.*—Valves B, C, and D are closed. The air is then drawn by the fan from the trunks through the valves E and F and then discharged to the atmosphere through valve A.

3. *A fresh supply of Air at Atmospheric Temperature.*—Valves A and E are closed. The air is then driven by the fan through the valves B, C, and D into the trunks and also to the compartments.

4. *Circulating Air through the Compartments.*—Valves A, B, C, and F are closed. The air is then drawn through valve E from one section of the trunks and is then driven through the tubes to the other section of the trunks, through valve D, thus maintaining a continuous circulation and heating the compartments very rapidly.

Plate XII. shows the arrangement of thermotanks as fitted on board Russian Volunteer Steamer "Kostroma," and also being supplied for the new steamers of the American Line, T.S.S.'s "Merion" and "Haverford."

Plate XIII. shows the arrangement as fitted on board the Japanese battleship "Asahi." In these arrangements, the controlling and regulating valves are all self-contained, and the adjustments made at the thermotanks instead of in the trunking below.

PATENT VENTILATING THERMOTANK (TEST AS A COOLER.)

Two sets were coupled up together, the air heated in the first being passed on to the second, through which water was circulated. The results are shown below:

Temperature of ingoing air.	Temperature of heated air.	Temperature of cooled air.	Temperature of cooling water.	Volume of air discharged per minute.
				Cubic Feet.
65° Fahr.	156° Fahr.	113° Fahr.	39° Fahr.	2846
75° ,,	158° ,,	112° ,,	,, ,,	2618
67° ,,	152° ,,	109° ,,	,, ,,	2782
68° ,,	137° ,,	98° ,,	,, ,,	2470
65° ,,	123° ,,	92° ,,	,, ,,	2633
64° ,,	121° ,,	87° ,,	,, ,,	2520
63° ,,	120° ,,	84° ,,	,, ,,	2431
57° ,,	60½° ,,	54° ,,	,, ,,	2431

The Table shows the results of some tests made at the works of Messrs. Matthew Paul and Co., Dumbarton, in order to show the value obtained in cooling, the circulating medium in this case being ordinary gravitation water at atmospheric temperature, viz., 39 degs. Fahr. at the time of test. Two thermotanks were coupled up together in series, one

of them heating the air by means of steam. The air was then passed through to the second thermotank, which cooled it down again by cold water circulation.

In looking over the scheme of distribution, as proposed by Mr. Jennings, for a ship on the lines of the "Kaiser Wilhelm der Grosse," it seems to the writer that he would find some difficulty in getting ship-owners or shipbuilders to find accommodation for the large trunks necessary.

By the author's figures, he proposes to distribute something like 17,000 cubic feet of air per minute from each fan, and as is well known, it is not advisable on account of noise to pass air through trunks at a higher velocity than 2,000 feet per minute, this would mean a trunk having a cross sectional area of eight and a half square feet coming down into the passenger accommodation. As the fore and aft trunks must be kept below beams, the consequent loss of head room would be very objectionable. Another drawback to the scheme is the great length of trunks proposed. Mr. Jennings would find in practice that even with an air pressure of 1·8 inches at fan discharge, the delivery of air from the openings at the far end of the trunks would be insufficient. He would also have difficulties with his temperatures, as it is found in practice that the upper deck rooms require more heat than those on the lower decks, hence, to warm the rooms properly on the upper decks, he would overheat the lower rooms and *vice versa*.

The system of distribution in connection with the thermotanks is very simple, as each unit deals with only about 5,000 cubic feet of air per minute, consequently the trunks are of comparatively short length and small cross section.

The trunks are led along the passage ways with louvres opening into the passages or led direct into the state rooms where the warmed or cooled air is delivered, thence, passing in the case of the rooms, from the venetian panels of the door to the ventilator, skid skylights, or stair ways leading to the top deck. If the weather is found to be suitable, then the whole system may be reversed in action, so as to exhaust air from the rooms, the ingoing air coming from the ventilators, or skids leading to the top deck or from ventilating side lights, which may be fitted.

This system only entails one half of the trunking which would be required in the scheme put forward by Mr. Jennings.

The writer thinks that for fan driving on board ship, especially for those in close proximity to state rooms, an electric motor is to be preferred to a steam engine, on account of the silent running of the former,

and the writer questions also if there would be any gain in economy of steam by using a steam engine.

The writer thinks that the adoption of artificial ventilation for ships would be greatly assisted by the Board of Trade taking up a stronger position in the matter, as, often when artificial ventilation is adopted, they still insist upon the usual complement of natural inlets and outlets.

113, WITHINGTON ROAD, MANCHESTER,

DEAR MR. DUCKITT, *January 1st*, 1901.

I think the Institution is much indebted to Mr. Jennings for his timely and well-illustrated paper. It has interested me a good deal, and I only regret that the paper was not much longer.

I fully agree with Mr. Jennings that the subject of ventilation is worthy of special study, and that the proper man to deal with it is a suitably trained engineer, working in harmony with an architect, whether naval or otherwise. I should be sorry, however, to undervalue the eminent services of such medical men as Drs. Arnott, Reid, and Billings, who were pioneers in the cause of ventilation, and whose works have been greatly instrumental in educating other men to appreciate the importance of the subject. Personally, I have found them very helpful.

It seems to me that a scientifically educated naval architect is more likely to appreciate the great advantages of good ventilation than is an ordinary architect, whose scientific knowledge is often of the scantiest. But unhappily the former is greatly trammelled by considerations of cost and by the inelastic rules of the Registration Societies.

That ships need better ventilation than is usual at present no sane person, I fancy, will deny. Much can be done in ventilating a ship by the use of downcast shafts provided with cowls, to act as inlets, together with a system of outlet trunks and pipes communicating with the funnel casing, the heat of which produces the desired circulation. This method utilises the motion of the ship to force air into its interior, but obviously the ventilation will vary with the speed of the ship, as well as with every change in the direction and force of the wind. Further, the question of heating, important in some trades, is left untouched. It is certain that ventilation cannot well be divorced from heating, at any rate in Atlantic passenger boats. Can Mr. Jennings tell us how the "Oceanic," the "Deutschland," and the "Campania" are heated and ventilated?

There are too many buildings, heated by either steam or hot water pipes, in which the ventilation is left to look after itself; with the most melancholy results from a hygienic point of view. Without doubt the most thorough method of both warming and ventilating a ship hitherto

devised is that of a forced circulation of air on the double duct system, part of the air being heated by a battery of steam coils, and mixed in any desired proportion with colder air. Our magnificent new technical school at Manchester is being heated and ventilated in this manner, which has the great advantage of being independent of the state of the atmosphere for its satisfactory working. A single duct system is not sufficient.

The system described is undoubtedly a costly one; but all high-class engineering work is necessarily costly. It should be evident that large volumes of a fluid cannot be heated and moved for nothing, whether that fluid be air or water. We never shall have a satisfactory atmosphere in crowded ships and buildings until public companies and municipalities come to recognise that money spent in providing a suitable hygienic environment is exceedingly well-spent.

Referring to the large passenger ship mentioned on p. 75, Mr. Jennings says that "the total heat loss was found to be about 720,000 calories per hour." It would be interesting to learn *how* this was found. Again, in the same paragraph he says that "the total amount of heating surface required in the steam coils for each apparatus would be about 60 square meters." Details of this calculation would also be instructive, and might form a suitable appendix to the paper. Taking the figures given, it appears that the weight of steam required for heating this ship is 4 × 1820 lbs. or 7,280 lbs. per hour. Assuming an evaporation of 8 lbs. of water per pound of coal, this means a consumption of 910 lbs. of coal per hour, or about 10 tons per day of 24 hours, for heating and ventilation.

I notice that Mr. Jennings has a preference for the use of metric units, rather than British, in his calculations. Would he be good enough to say whether this is the custom of his firm.

There would appear to be a great future before the forced-blast system of heating and ventilating, both afloat and ashore, and it seems rather remarkable that this branch of engineering should be practically confined to one firm, at least in England.

Yours faithfully,

W. H. ATHERTON.

ETON VILLA, CATHCART,

DEAR MR. DUCKITT, *February 5th*, 1901.

Having only received a proof copy of Mr. Jennings' paper on Saturday, I may be somewhat late to join in the discussion, but if it has not yet closed I would like to offer a few remarks relative to the very

important subject of the ventilating and heating of ships, which he has brought before the Institution.

Mr. Jennings devotes his paper principally to that system, in which the heating and ventilating is combined by the circulation of warm air throughout the ship. To illustrate the application and efficiency of this system, reference is made to the heating and ventilating arrangements fitted on board several Dutch war vessels, but beyond stating that the results "proved very satisfactory," no information, of any kind, is given to show what these results actually were. Such a description of the results is, I think, too vague upon which to place much reliance; too indefinite to enable a shipowner or naval architect to determine which, of various systems, is most suitable to adopt in any particular case; and, it would therefore be preferable if we had before us a statement in definite terms showing the ventilation efficiency, coupled with the actual temperatures at various parts of the ship, in cabins, wardrooms, etc.

I am led to make these remarks because I spent some days on board one of the Dutch cruisers referred to, during the month of January, and again during the month of April, when the weather was very cold, and I must say that to describe the results as I felt them, as having "proved very satisfactory," would not conform with my idea of that degree of excellence.

The ship was almost exactly the same in general dimensions and equipment to British second-class cruisers of the "Flora" class, the dimensions of the engines were likewise similar, but having greater boiler power, the horse power was greater. The fans and heating pipes were similar to those described by Mr. Jennings, and were situated on the main deck close to the engine room hatch. Cabins were ranged along each side of the ship, with the ward room at the end of the passage remote from the fan, there being additional cabins beyond that again. The cabin which I occupied was situated in the passage referred to, about 30 feet from the fan; while that farthest from the fan on the same deck would be about 150 feet away. I am not aware that actual temperatures were recorded during the time that I was on board, but I have a vivid recollection that the temperature in my cabin and its immediate vicinity was too high to be comfortable, and at a moderate estimate would range from 70 degs. to 75 degs. Fahr.; while in those cabins about 130 feet away, it was generally too low in which to sit with comfort and almost impossible to write for any length of time, or probably about 40 degs. Fahr. Before those cabins which were farthest from the fan could be maintained at an agreeable temperature,

those in its vicinity had become insufferably hot. Cabins were shut off which were not in immediate use, and search was made more than once to see if any leakage was the cause, but none was found, nor was a cure effected. Heating compartments under such a system can neither be healthy nor safe; indeed, to leave one's cabin and go directly on deck after such a roasting as one got near the fan, was simply courting trouble.

With regard to the ventilating pipes, I would be disposed to reverse Mr. Jennings' description as appearing more intricate and difficult to work in on paper than it is in reality; and here again, I may add, that a few actual figures would have been useful. It is a comparatively simple matter to draw in a series of thick black straight lines extending from end to end, and from side to side of a ship's plan, but when it is pointed out that those thick lines represent rectangular pipes which may vary in dimensions from about 20 inches by 6 inches to about 8 inches by 6 inches, it will be apparent that it is no simple matter to arrange these underneath deck beams to look neatly even when the naval architect collaborates with the ventilating engineer from the outset of the design. What it might turn out when fitted as an afterthought, when pipes and other fittings have to be cleared, I would not like to say, but it is evident that even Mr. Jennings has a dread of such a contingency.

In conclusion, let me repeat that a few figures relative to the points I have mentioned would enhance the value of Mr. Jennings' paper considerably, and if he can add those in his reply, especially with reference to the loss of temperature which has been found with warm air flowing through thin metal pipes in a given distance; also, the average state of the atmosphere, I am sure that the Institution would be further indebted to him.

Yours faithfully,

JAMES ANDREWS.

The discussion was declared closed, the reply to be taken at a subsequent meeting.

ON SOME ATTEMPTS TO INCREASE THE EFFICIENCY OF MARINE BOILERS.

By G. M. BROWN, B.A. (Cant.), B.Sc. (Dun.), Wh. Sch.

[Read before the Institution in Newcastle-upon-Tyne, on February 1st, 1901.]

At the outset it is desirable to state that this paper is not a discussion of the relative merits of the various systems of forced and induced draught at present in use, but rather of some other improvements, and that its object is chiefly to provoke a discussion on those improvements and the possibility of a further increase in the efficiency of marine boilers.

In 1857, the late Lord Armstrong and two other gentlemen were appointed to carry out a series of experiments on the respective values of North Country and Welsh coals for marine purposes. The result of their labours was the famous Newcastle experiments. The boiler they used was one of the old, wet bottom type, with an internal uptake, and a feed heater at the base of the chimney, which reduced the temperature of the waste gases by about 50 degs., and steam was generated at atmospheric pressure. Under such conditions it was possible to attain a very high efficiency, as the following figures show :—

	Water actually evaporated per lb. of coal.	Evaporative power of coal (by calorimeter).	Efficiency. Per Cent.
Aberaman Welsh coal, hand-picked	12·35	14·30	86·5
Hartley coal, large and small ...	12·91	14·63	88·2

Shortly afterwards, similar experiments were carried out on the same boiler, by Messrs. Millar & Taplin, on the boilers of the s.s. "Isabella Croll," by Mr. Dobson, and on the Keyham Factory Boiler. A full account of all these trials will be found in *The Steam Engine*, by D. K. Clark, vol. i. The general result obtained was, that a fairly rapid rate of combustion gives the best results, provided the grate area is not large. Since then other tests have been made, but still the major part of the data available to the marine engineer is very old. It is to be regretted that those who have made tests of more modern boilers have, with a

few exceptions, either not taken all the necessary data to render their results of practical value, or have not thought fit to publish their results for the benefit of their fellow-workers.

The last two decades have seen an enormous change in the marine engine, but the same boiler is still in general use, neglecting a few structural changes necessitated by the greatly increased pressures lately introduced. So far the steam engine has had every attention, and it is certain that no great increase of efficiency can be obtained by increasing the working pressure. On the other hand, the boiler, the efficiency of which is every whit as important as that of the engine, has had comparatively little attention paid to it; few people have studied its action or endeavoured to increase its efficiency. Especially is this the case with the marine boiler as now used; indeed, so far as the writer is aware, no complete measurements of the temperatures and pressures of the products of combustion as they pass from the furnace to the chimney have ever been made. It is very questionable whether, with the increased pressures now in use, the efficiency of the ordinary marine boiler is not, in general, much less than it was formerly, for these increased pressures have necessitated the abandonment of the feed heater at one time commonly used in marine work and fitted in the uptake so that it abstracted heat from the chimney gases. That this is a retrograde step there can be no doubt whatever; in the writer's opinion such a feed heater would be a much more valuable adjunct to the high pressure boilers in present use than it was in the case of the old low pressure boilers.

It is humiliating to engineers to think of the great waste of energy going on about them, and more especially of that waste wilfully allowed to go on because it is supposed to be necessary to create a chimney draught by allowing a large mass of highly-heated gases to pass away from the boiler and carry with it somewhere about 20 per cent. of the heat generated by the coal consumed in the furnaces. Temperatures of 700 degs. Fahr. and more are common in the uptakes of ordinary marine boilers working with natural draught and having plain tubes.

Assuming this temperature to exist at the base of a funnel 65 feet high and taking the atmospheric temperature to be 62 degs. Fahr. we have from the formula*

$$w = H\left(\cdot 0146 - \frac{7\cdot 66}{T + 461}\right)$$

where w = draught in inches of water
H = height of funnel in feet
T = temperature of gases

* *The Steam Engine*, D. K. Clark, vol. i., p. 371.

$$w = 0{\cdot}52 \text{ inch of water}$$

which is distributed as follows :—*

		Inch.
Resistance due to the funnel, uptakes and smoke box ...		0·02
,, ,, tubes		0·11
,, ,, fire-box, bridge, furnace		0·06
,, ,, fire of moderate thickness		0·31
,, ,, inertia of column of gases		0·02
	Total	0·52

Theoretically about 11 lbs. of air are required for the complete combustion of 1 lb. of coal, the result being 12 lbs. of a mixture of carbon dioxide, steam, and nitrogen. The amount of air actually supplied to the furnaces of boilers working under natural draught is sometimes as great as 2½ times the theoretical quantity. If we assume that 19 lbs. of air are required for the combustion of 1 lb. of coal there will be practically 20 lbs. of gaseous products having an average specific heat of about 0·23. Then of the heat generated by the combustion of 1 lb. of coal (average say 14.700 BTU).

$$20 \times 0{\cdot}23\ (700-62)$$
$$= 2934{\cdot}8 \text{ BTU.}$$

or about 20 per cent. is used in creating a draught. It is evident that the ordinary method of producing a draught is a most wasteful process, especially when it is remembered that with forced or induced draught the percentage of the heat of combustion required to work the fans at a consumption of 30 lbs. of coal per square foot of grate is about 3 per cent. according to Bertin, although Messrs. John Brown & Co. assert that in some of their larger installations which have triple expansion fan-engines it is only about 1·3 per cent.

When we consider these figures it becomes evident that there will be some advantage in utilizing the heat of the waste gases otherwise than to create a draught even if, as will generally be the case, we are thereby compelled to use an artificial draught. Of the several methods of doing this, perhaps the most obvious is to increase the length of the passage through water as was done by Audenet. The objection to this is the great length by which the passage has to be increased to produce any appreciable saving, as can be seen from the experimental results of M. Henry,† locomotive superintendent on the Paris-Lyons-Mediterranean Railway, which are quite in accordance with those of Woods and Dewrance,‡ C. W. Williams§ and M. Petiet.‖

* *Marine Boilers*, Bertin and Robertson, p. 57. † *Ibid.*, p. 131.
‡ *Engineer*, March 19, 1858, p. 224. § *Trans. I.N.A.*, 1862, p. 122.
‖ *Proc. I.C.E.*, vol. xxxix., p. 398.

In the early days of marine engineering considerable economy was effected by superheating the steam as it passed from the boiler to the engine. As boiler pressures increased much trouble was experienced with the superheaters and in the engines, and this plan fell into disuse. It has, however, lately been renewed in steamers of the "Inch" line owned by Messrs. Hamilton, Fraser & Co., and engined by the Central Marine Engine Works, of West Hartlepool. But with the pressures in use at present the temperature of the superheated steam is high, for instance in the s.s. "Inchkeith," the boiler pressure is 260 lbs. per sq. inch, the temperature of the steam at the inlet to the superheaters is about 400 degs. Fahr., the temperature of the waste gases at the smoke box is about 650 degs., and above the superheater about 450 degs. Fahr., so that as far as superheating alone is concerned we are compelled to let the gases go at a fairly high temperature, although not nearly so high as that common in many boilers working under natural draught.

Another device largely adopted on old low pressure boilers was the feed heater fixed in the base of the chimney, but owing to the pitting and corrosion which took place these heaters, more especially as boiler pressures increased, were a great source of trouble and danger, and their use was accordingly dispensed with. The late Mr. Ebenezer Kemp, of Glasgow, however, persevered with them. In several boilers for the "Clan" line he used small coils by means of which the feed water was raised about 40 degs. in temperature and the waste gases reduced in temperature, but his first serious work in this direction seems to have been done on the s.s "Bléville," into which he fitted heaters having a collective heating surface about double that of the boilers, and also an exhaust fan at the base of the funnel. He succeeded in reducing the temperature of the waste gases from 1040 degs. Fahr. to 356 degs. Fahr., and in raising that of the feed water from 120 degs. Fahr. to 360 degs. Fahr. The hot gases were thus discharged at a temperature of 236 degs. Fahr. above that of the incoming feed water. The usual troubles through corrosion and pitting of the tubes soon led to the abandonment of this plan. In the s.s. "Caloric" Mr. Kemp adopted the closed ashpit system of forced draught, and as feed heaters used four small cylindrical boilers. In this case the gases left the smoke box at 680 degs. Fahr., and after passing through the feed heaters had a temperature of 236 degs. Fahr. The temperature of the water was raised about 36 degs. Fahr. in each feed heater, *i.e.*, 144 degs. Fahr. in all. In this case also there was some trouble through the corrosion of the tubes near the feed water inlet. Soon after Mr. Kemp retired from practice and his idea seems

to have been abandoned, but has been recently revived in the Navy, H.M.S. "Diadem" having a feed heater above each of its Belleville boilers.

Perhaps the most satisfactory method of utilising the heat of the waste gases is that adopted by Mr. Howden in his closed ashpit system of forced draught, and Messrs. Ellis and Eaves in their system of induced draught, that is to heat the air necessary for combustion. The advantage of supplying heated air is that more perfect and immediate combustion is ensured, but it has been asserted against this that the heat of combustion diminishes as the temperature increases.* After careful enquiry the writer is unable to substantiate this statement, which seems to be based on the supposed dissociation of the products of combustion at high temperatures, first investigated by Saint-Claire-Deville,† and afterwards by Bunsen, Victor Meyer, and others. What these authorities regarded as evidences of dissociation are attributed by Siemens‡ to imperfect combustion due to the action of the sides of the vessel in which combustion takes place, to support which statement he adduces the results of Saint-Claire-Deville and other supporters of the dissociation theory. The result of dissociation would be to impose a limit to the temperature obtainable in a furnace, and the existence of this limit is denied by Siemens, who states that provided there is ample room for combustion to take place there is no such limit. This is a question to be settled by chemists; nevertheless, the experience of Siemens with his regenerative furnaces is all in favour of roomy furnaces and combustion chambers.

Another method of abstracting heat from the products of combustion is to increase the heat absorbing surface of the boiler. In 1840, Mr. C. W. Williams patented the application of "conductor pins" to heating surfaces.§ The pins were fixed perpendicularly to the heating surface so that the hot gases impinged directly on them. The superior efficiency of a heating surface fitted with these pins was clearly demonstrated in the following manner :—into three tin boilers, each with an internal flue, twenty-two pounds of water at 58 degs. Fahr., were measured, and then the products of combustion of 30 cubic feet of gas were passed through each in turn, the gas in each case being consumed in 2 hours 40 minutes, with the results :—

* *Marine Boilers*, Bertin and Robertson, p. 80.
† *Leçons de Chimie.*
‡ *Journal of the Society of Chemical Industry*, 1885.
§ *On the Combustion of Coals*, C. W. Williams, p. 216.

No. 1.	Plain	evaporated	4·25	lbs. of water.
No. 2.	With conductors on outside only	,,	7·90	,, ,,
No. 3.	,, ,, inside and outside ...	,,	8·31	,, ,,

The temperatures of the escaping gases being 406 degs. Fahr., 320 degs. Fahr., and 284 degs. Fahr. respectively. A later development of this principal is seen in the Serve tubes to which Messrs. Ellis & Eaves largely attribute their undoubted success. By means of the internal ribs in these tubes the heat absorbing surface is increased by 75 per cent. more than that of a plain tube of the same dimensions. In consequence of this it is stated by the makers that when a boiler is fitted with 3¼ inch Serve tubes, 7 feet long, the temperature of the gases in the smokebox is the same when the ratio of heating surface (calculated in the ordinary way) to grate surface is 28 to 1 as with 40 to 1 and plain tubes, a difference of about 43 per cent. in favour of the Serve tube. The experiments of the late Mr. Blechynden* shew the Serve tube to be 33 per cent. more efficient than the plain tube.

Messrs. J. Brown & Co. use with the Serve tube, spiral retarders, for the purpose of breaking up the column of gas passing through each tube and bringing it into intimate contact with the heating surface, as also does Mr. Howden. The effect of introducing a spiral retarder into a boiler tube is to compel the gaseous products of combustion to follow a very tortuous course, and if there is not a very strong draught through all the tubes, solid matter, such as fine ash and unconsumed carbon, is deposited in the tubes with the result that the lower rows rapidly become stopped up and useless, and a large portion of the heating surface is thrown out of action and the power and efficiency of the boiler are diminished.

It is a well known fact that in all return tube marine boilers the lower rows of tubes rapidly become stopped up, the reason being that the draught through them is very sluggish. The hot products of combustion pass over the bridge with a velocity of about 4,500 ft. per minute and impinge on the back of the combustion chamber, where they spread outward and upward. The main part flows up the back of the combustion chamber round the top and into the upper rows of tubes, the rest passing up the sides and out of the upper side rows of tubes. The cooler and unconsumed portions follow a shorter path, and are drawn into the lower rows of tubes where their combustion becomes impossible. It is evident that if the hot gases are compelled to take a longer path and are more thoroughly mixed together before entering the

* *Engineering*, October 15th, 1894, p. 461.

tubes, as they must do if the upper rows are wholly or partially plugged up, combustion will be rendered more perfect. Moreover, the greater the evaporation from the lower rows of tubes the better will be the circulation of the water in the boiler, and hence, for a double reason, we may expect the efficiency of a boiler to be increased by properly regulating the amounts of the hot gases passing through the various tubes. That this reasoning is true is borne out by the fact that in many steamers using spiral retarders they are removed from the lower rows of tubes and the performances of the boilers thereby improved, and also by the experiments of Mr. Isherwood* both on large and small marine boilers.

In 1864 he conducted a series of experiments on a small, new and clean marine boiler, to test the influence of various arrangements and proportions of heating surfaces, and of various rates of combustion. The boiler was rectangular in shape with a semicircular top, and was 3 feet 1½ inches wide × 6 feet 7 inches long × 6 feet 5 inches high, with one furnace 26 inches diameter and 24 tubes 3 inches external diameter and 5 feet 10½ inches long, arranged in 4 rows of six each, and the following results were obtained.

First Series :—Varying heating surface of tubes and tube section by plugging up rows of tubes at both ends. Grate area 10·89 square feet. Combustion about 16·5 lbs. per square foot per hour.

State of Tubes.	Heating Surface.	Surface Ratio.	Tube Sections.	Water per lb. of Coal from and at 212°
	Square Feet.		Square Feet.	
Normal	150·3	14	·99	6·78
Lowest row plugged	125·1	11·58	·64	6·33
2 rows ,,	99·9	9·25	·495	7·00
3 ,, ,,	74·72	6·92	·25	6·71

Second Series :—Tube surface as above. Rate of combustion proportional to heating surface.

State of Tubes.	Lbs. Coal per 48 Hours.	Lbs. Coal per Square Foot of Grate.	Coal per Square Foot of Heating Surface.	Water per lb. of Coal from and at 212°.
Normal	8591	16·57	·969	6·78
Lowest row plugged	7127	13·75	·993	7·04
2 rows ,,	5720	11·03	1·009	7·57
3 ,, ,,	3876	7·48	·912	9·28

* *Experimental Researches in Steam Engineering*, 1865, vol. ii. p. 397.

Third Series :—Constant grate area, heating surface, and rate of combustion. Tube section varied by inserting ferrules in both ends of all tubes.

Ferrules ½ inch Long.	Tube Section.	Lbs. Coal per 48 Hours.	Lbs. Coal per Square Foot of Grate.	Water per lb. of Coal from and at 212°.
	Square Feet.			
—	·99	8591	16·57	6·78
$\frac{3}{16}$" Thick	·738	8659	16·53	6·85
$\frac{7}{16}$" ,, ...	·460	8612	16·61	6·85
$\frac{1}{4}$" ,, ...	·204	2999	5·79	8·59

In 1863 he conducted experiments* on the effect of plugging up tubes in a marine boiler, 12 feet long, 7½ feet wide and 12 feet high, with two furnaces 3 feet wide, and 144 tubes 3 inches ext. diam., and 8 feet 3 inches long, there being nine rows of eight tubes to each furnace. The combustion chambers were not large. The first series of trials was made with the boiler (1) in its normal state, (2) with two upper rows, (3) with three upper rows, (4) with four upper rows of tubes successively plugged up at both ends, with the following results :—

	1.	2.	3.	4.
Coal per square foot of grate per hour, lbs.	11·6 ...	13·3 ...	9·8 ...	10·5
Water, per lb. of coal from and at 212° lbs.	8·4 ...	8·9 ...	9·8 ...	9·9
Temperature in uptake	432° ...	544° ...	541° ..	616°

The second and third series were made with a different coal. In the second set the boiler was (1) in its normal state, (2) with two lower rows, (3) with three lower rows, (4) with four lower rows of tubes successively plugged at both ends :—

	1.	2.	3.	4.
Coal per square foot of grate per hour, lbs.	13·9 ...	12·4 ...	13·1 ...	12·9
Water, per lb. of coal from and at 212°, lbs.	9·3 ...	8·3 ...	9·4 ...	9·6
Temperature in uptake	460° ...	453° ...	575° ...	603°

In the third series the boiler was (1) in its normal state, (2) with two inner vertical rows, (3) three inner vertical rows, and (4) four inner vertical rows of tubes plugged at both ends :—

	1.	2.	3.	4.
Coal per square foot of grate per hour, lbs.	11·6 ...	12·4 ...	13·2 ...	12·8
Water from and at 212°, per lb. of coal, lbs.	9·3 ...	8·5 ...	9·4 ...	9·3
Temperature in uptake	460° ..	478° ...	568° ..	597°

* *Experimental Researches in Steam Engineering*, 1863, vol. i. p. 295.

Similar experiments were carried out by Mr. Isherwood on the boilers of the U.S. steamer, "Jacinto," with analogous results.

It has been stated that the results of the above experiments shew the tube surface to be practically useless so far as steam raising is concerned. It is only necessary to consider them side by side with those of M. Petiet to see the baselessness of such an assertion. What is more probable is that the reduction of tube section entails the admission of less air per b. of coal burnt and more perfect combustion, especially with the upper rows of tubes plugged up, as well as a higher velocity of the gases over the surface of the tubes, a condition known to be favourable to their efficiency.*

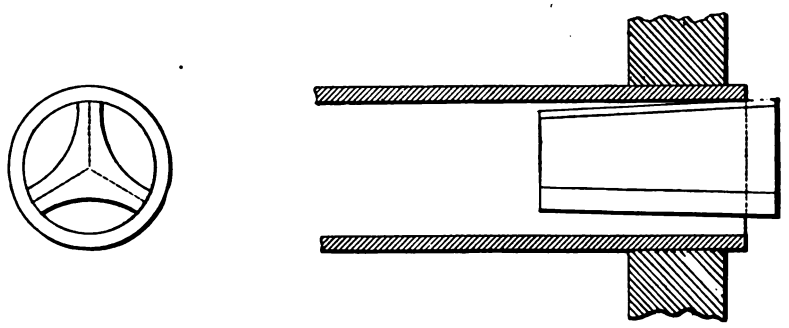


FIG. 1.

The one thing these figures do point out is the desirability of using small tubes in boilers and thus obtaining a large amount of heating surface, small tube section, and high velocity of the gases through the tubes, the latter condition being the most important, but unfortunately for practical reasons this is not feasible, and marine engineers are compelled to use large tubes. Whether the large tubes are Serve tubes or not experience has shewn the desirability of reducing the area for the passage of the hot products of combustion preferably by means of some form of retarder.

There are several forms of retarder in use. One of the first to be introduced was that of Mr. N. Hawks. These are merely metal plugs of the shape shewn in Fig. 1, and are made with a fair taper to meet slight inequalities in the sizes of the tubes.

Recently another retarder on the same principle has been put on the market (West's patent). It is a light sheet metal stamping in the

* Stanton, *Phil. Trans.*, 1897, and Osborne Reynolds. *Proc. Lit. and Phil. Soc. of Manchester*, 1874.

shape of a disc with four prongs, and is not calculated to prove very durable.

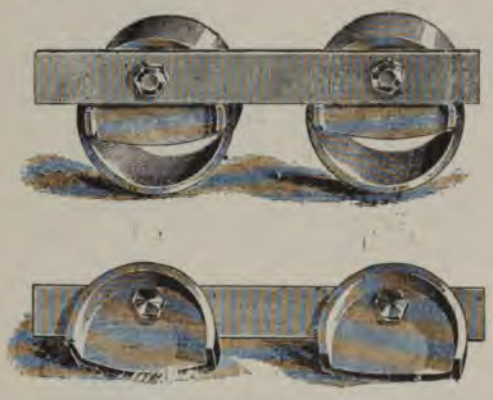


Fig. 2.

Spiral retarders are well known and require no description. In many cases a great saving of fuel has been brought about by their use, but they are somewhat clumsy to handle in the stokehold. One advantage they have is that the tubes may sometimes be partially cleared by working them in and out.

Mr. John Scott has recently introduced a form of retarder (Fig. 2) which has several advantages, the chief being that the area left in each row of tubes

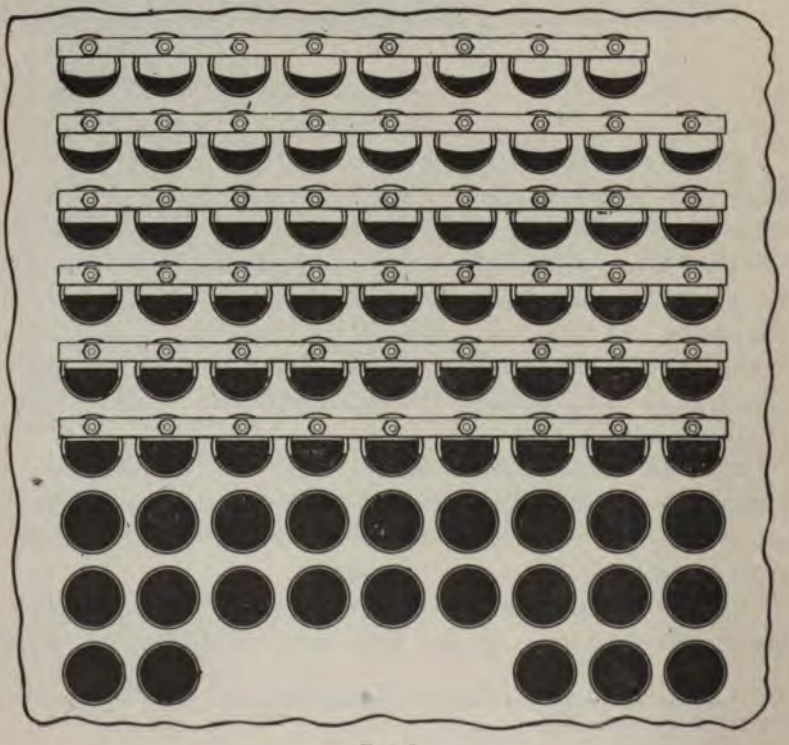


Fig. 3.

for the passage of the products of combustion may be regulated so as to secure the best results. Being bolted together in rows as shewn in Fig. 3 they are easily and expeditiously removed from the tubes when necessary and occupy less space in the stokehold. From the fact that the flow of the products of combustion through the various tubes is regulated we might expect these retarders to be if anything more efficient than the spiral retarders, even although they do not bring the hot gases into such close contact with the tube surface. The following are the results of three tests carried out on a boiler 10 feet 6 inches diameter × 10 feet 6 inches long, with two Purvis' Patent Flues 2 feet 10½ inches diameter, and 126 3¼ Serve tubes 7 feet 6 inches long, with no retarders, with spirals, and with Scott's Patent Economizers. The boiler was worked under Messrs. Ellis & Eaves system of induced draught.

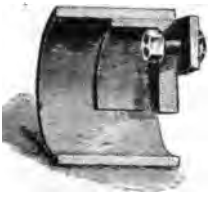


FIG. 4.

	No Retarders.	Spiral Retarders.	Scott's Patent Economizers.
Length of trial	6 hours	6 hours	6 hours
Coal burnt in lbs. ..	8,960	8,960	8,960
Water evaporated, lbs. ...	67,000	76,900	77,600
Temp. of feed water ..	52·9	58·6	57·5
Steam pressure in lbs. ...	47	46	47
Temp. of air at side valve	332·9	312·2	342·7
Temp. of gases at base of chimney...	470·4	422·2	465·9
Temp. of gases in smoke-box	melted lead	just melted lead	melted bismuth
Vacuum at base of chimney, inches of water ...	3·93	4·26	4
Vacuum at fan outlet, inches of water	·25	·35	·375
Speed of air under grate bars, feet per minute ...	2,645	3,000	2418·1
Speed of air through heating tubes, feet per minute	1272·7	1,318	1090·9
Lbs. of water per lb. of coal from and at 212° ...	8·89	10·16	10·27

These are the only figures relating to systematic tests on retarders he writer has been able to obtain.

The following are the mean results of ten voyages made by a steamer running in the cross Channel trade before and after fitting retarders. The ship has two single-ended boilers each with three furnaces, and one single-ended boiler with two furnaces, all having tubes 3¼ inches diameter, and working under natural draught. The data given are thoroughly reliable as the coals were accurately weighed.

	Without Retarders.	With Scott's Patent Economizers.
Consumption of coal per voyage, tons ...	29·9	27
Average revs. per min.	70·5	69·2
Time on passage	12 hrs. 20 mins.	12 hrs. 12½ mins.

The figures in the first column are the averages for the best ten voyages in the two and half years preceding the fitting of the economizers, and in the second column for the ten consecutive voyages after the retarders were fitted; they shew a saving of 9·7 per cent. in coal, and 1 per cent. in time in favour of the retarders.

With regard to ships making longer voyages, the following figures are abstracted from the engineers' logs for three voyages of a ship, No. 1 before the vessel was fitted with retarders, and Nos. 2 and 3 after fitting with Scott's Economizers.

Voyage.	Total full speed steaming time.		Average Daily Consumption.		Average Speed.	Knots per Ton of Coal.	Total coal used for Main Engines.
	Days.	Hours.	Tons.	Cwts.	Knots.		
No. 1.	44	18	21	18	9	9·7	977
No. 2.	46	1	19	0	9·3	11·6	877
No. 3.	45	1	17	14	8·8	11·7	803

Comparison of Voyages Nos. 2 and 3 with Voyage No. 1.

	Daily coal consumption reduced. Per Cent.	Average speed increased. Per Cent.
Voyage No. 2.	13·3 ...	3·3
,, No. 3.	19·2 ...	−2·3

The above figures shew very clearly the benefits to be derived from the use of a proper outfit of retarders.

Owing to lack of time, the writer has been unable to collect data bearing on the performance of other types of plugs and retarders. It is only in Mr. John Scott's system that any attempt is made to regulate the distribution of the products of combustion; in other types the same retarder is put into all the tubes, except perhaps the two bottom rows. The greatest saving is effected in fitting retarders into boilers with large

tube section, and, to derive the utmost benefit from their use, the combustion chambers should be large and roomy ; and hence any brickwork at the backs of the chambers should be removed. Indeed, roomy combustion chambers are essential to the efficiency of a boiler, whether retarders are put in the tubes or not.

Lately Messrs. J. Brown & Co., working in conjunction with the Central Marine Engineering Co., have made a notable advance in using the waste gases, not only to heat the air supplied to the furnaces, but also to superheat the steam generated in the boilers. This system is applied on the s.s. "Inchkeith," s.s. "Inchmarlo," and others, and an idea of the increased efficiency of this system, compared with the primitive natural draught, can be formed when it is stated that in the "Inchkeith" the chimney gases have a temperature of 380 degs. Fahr. only,* and the s.s. "Inchmarlo," which is fitted with the Central Marine five crank engines, on a recent trip from Hartlepool to Dover only burnt 0·97lb. of coal per I.H.P. per hour.† It is open to question whether a further saving might be effected by passing the waste gases through a feed heater, and reducing their temperature still further. Compared with the 236 degs. Fahr. attained by Mr. Kemp, 380 degs. Fahr. is still a high temperature at which to allow them to escape, and, by passing them through a feed heater, it might be possible to effect a further saving of about 3 or 4 per cent.

In conclusion, the writer can only say that he hopes his imperfect and hurriedly written paper will be productive of a good discussion, more especially since this Institution has so many members who take a prominent part in the improvement and development of the marine engine and boiler.

The discussion was deferred, and the meeting dissolved.

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* In making a comparison of chimney temperatures under natural and forced draughts, it is well to remember that a much smaller quantity of air is generally required per lb. of coal with the latter than with the former, especially with a heated air supply.

† *Engineering*, January 4th, 1901, p. 9.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SEVENTEENTH SESSION, 1900-1901.

PROCEEDINGS.

FIFTH GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE TECHNICAL COLLEGE, WEST HARTLEPOOL, ON SATURDAY, MARCH 2ND, 1901.

On the motion of Mr. M. C. JAMES, seconded by Mr. W. C. BORROWMAN, Mr. R W. Vick, was, in the absence of the President, called upon to preside.

The CHAIRMAN said he should like to express regret that his friend and partner, Mr. Henry Withy, J.P., the President, was absent from home, and consequently could not take the chair that evening. He had much pleasure in trying to occupy his place.

The ballot for new members having been taken, the Chairman appointed Mr. W. C. Borrowman and Mr. M. C. James to examine the ballot papers, and the following gentlemen were declared elected :—

MEMBERS.

Marshall, Robert, Engineer Surveyor, 12, Broughton Road, South Shields.

Munro, James, Engineer, c/o Messrs. Hawthorn, Leslie & Co., Hebburn-on-Tyne.

Proven, George, Engineer, 358, Leith Walk, Leith, N.B.

Roberts, W. C., Supt. Engineer, 18, Windsor Road, Forrest Gate, Essex.

Tose, Thomas, Engineer, 30, Thornton Street, West Hartlepool.

GRADUATE TO MEMBER.

Wilson, William S., Electrical Engineer, 123, Osborne Road, Jesmond, Newcastle-upon-Tyne.

ASSOCIATES.

Stallybrass, William S., Merchant, 14, Side, Newcastle-upon-Tyne.
Temple, John, Marine Surveyor, Baltic Chambers, Newcastle-upon-Tyne.

GRADUATE.

Little, Alvin, Engineer, 39, Leazes Terrace, Newcastle-upon-Tyne.

THE ADDRESS TO THE KING.

The SECRETARY (Mr. John Duckitt) said in reply to the address adopted at the previous meeting, he had received the following communication from the Home Secretary :—

HOME OFFICE,
WHITEHALL,
16th *February*, 1901.

SIR,

I am commanded by the King to convey to you hereby His Majesty's thanks for the Loyal and Dutiful Address of the North-East Coast Institution of Engineers and Shipbuilders, expressing their sympathy with His Majesty and the Royal Family on the occasion of the lamented death of Her Late Majesty, Queen Victoria.

I am, Sir, your obedient servant,
(Signed) CHAS. T. RITCHIE.

The SECRETARY,
N.E. Coast Institution of Engineers and Shipbuilders,
4, St. Nicholas Buildings,
Newcastle-on-Tyne.

The discussion on Mr. G. M. Brown's paper on "Some Attempts to increase the Efficiency of Marine Boilers" was resumed.

Mr. WALTER SCOTT read a paper on "Some Remarks on the Commercial Organisation of Shipyards."

DISCUSSION ON MR. G. M. BROWN'S PAPER ON "SOME ATTEMPTS TO INCREASE THE EFFICIENCY OF MARINE BOILERS."

Mr. A. M. HENDERSON said he was sorry they had such a small meeting, as Mr. Brown's paper opened such a wide field for discussion, and gave opportunities of throwing fresh light on many points, but he was afraid there would be no fair chance of dealing with it. He had not heard the paper read, and had only been able to take a cursory glance at it; but he noted there were a great many points all tending to one thing, that was the economising of fuel. He mentioned one of his (Mr. Henderson's) earliest friends, Mr. Kemp, and with respect to his first attempt, twenty-eight or twenty-nine years ago, in feed heating, he struggled on very manfully with it, and, as they were all aware, he met with the one great trouble which was mentioned in the paper, viz., corrosion. Still, he did not give it up, and he (Mr. Henderson) believed, in his latter days, he was making some headway with it. One unfortunate thing crept in, as it will always, and that was non-commercial success. The increased cost of appliances damped the whole thing. With regard to heat and feed water, they all knew the action that took place when the feed heater was in pipe form, the pipes corroded and became dangerous. To avoid that, to his mind, there was no other way than to extract the air. This would mean additional apparatus for the purpose, and, of course, could be got, but it cost money, and the desideratum at the present time was, in many cases, a cheap article, though it might not always be an economical one. The paper, of course, dealt very largely with the construction of boilers. Well, the construction of the present boiler was so well known, it needed very little remark. They all knew its faults, but they wanted the remedies. It was what was called the Scotch type. Why it should be called that he did not know. It had been much modified in many cases. It was the old original type, however, and the main features were still closely followed in the construction of the boiler at the present time. They had machinery powerful enough to build the best boiler ready for the test, to stand the higher pressures that were used. Then the question came in about the production of plates, etc., that had to be met, and had been met to a certain extent up to $1\frac{9}{16}$ and $1\frac{5}{8}$ inches thick. There was a great deal of expense in producing boilers that thickness. The shell

and the work put on them must be excellent, *par excellence*, in fact. Of course, with regard to the practice in the Central Marine Engine Works, they built a special boiler to deal with high pressure. They had found no great difficulty in withstanding a pressure of 250 and 260 lbs., and these had been working for the last five years without giving any trouble. In producing these boilers they had to take extra time and great care ; that, of course, increased the cost of production. They had to obtain the very best in the shape of material, and all tended to the one thing, increased cost. After all, after trying all, they found still the same thing staring them in the face, and that was, supposing they reduced the consumption of fuel, someone wanted it still lower. With regard to actual practice, the writer of the paper mentioned the "Inchkeith" and the "Inchmarlo." It was pretty well known now what they could do ; and with regard to their performances there was no doubt in his mind and others that they could be bettered and bettered very considerably, but there were one or two things that had to be met. In the first place, they could superheat steam, he took it, much higher than at the present time, without doing very much damage to the vessels carrying it, but immediately they rose to a given point with the present condition of cylinders, valves, &c., then they had increased dry heat in cylinders and they had not got a lubricant that would meet it. He was safe in saying that the temperature reached in the "Inchkeith" and "Inchmarlo" was not more than 460 degrees, if they went beyond that, say to 500 or 520 degrees, they at once set up an action in the engine which very soon spoke for itself in the shape of a dry grunting sound, and, of course. they had to drop it at once. That being got over there was no necessity to keep down the temperature, and it could easily be got by additional superheating surface and, in doing so, reducing the temperature of gases leaving the uptake ; but, as the writer here remarked, why not carry away the waste gases to the feed heater ? The same thing came in again—the corrosion of the pipes. The one great drawback was that with intense pressure copper pipes would not stand and iron pipes corroded very much In the boats of the "Inch" line, the feed water was heated to a high temperature ; and no doubt it could have been heated more with by-products from the boilers ; but to get that he was afraid they would have to add additional mechanism for abstracting the air. That went into expense again, and at all ends they were met with this—engineering could do a great deal, but engineering at the present day must be a commercial success or it was non-existent. With regard to

the shapes and forms of boilers one might have dreamt of a good many things that could be done. They knew with oil fuel a great deal could be done and boilers altered very considerably. Then he might say "Why not?" They produced crude gas and used it in their works, why not produce that and utilise it in the boiler with the combustion chambers outside? Several other things might be done: but it remained yet for a genius to be found to couple the whole thing together and produce simplicity and efficiency. Of course it was only by meetings such as these, and with each one communicating his views, that this end could be reached, or at least brought nearer.

Mr. W. C. BORROWMAN said the paper was one which indicated a great deal of careful research on the part of Mr. Brown, and ought to be of much use to the younger members of the Institution who desired to know where to find information concerning marine boilers. Mr. Brown had made reference to some recent practice as carried out at the Central Marine Engine Works, and in this Mr. Brown made the slight mistake of characterizing this as an attempt at higher efficiency, because they had got beyond the mere attempt stage, and had attained to a higher degree of efficiency in marine boilers than had ever been experienced before. Was Mr. Brown quite right in stating that the efficiency of the modern marine boiler was now lower than that obtained in the old-fashioned types, due to the absence of feed heating? As far as the speaker's experience carried him, feed heating was being carried to a much higher degree than ever it was before, and with highly satisfactory results. In the system of feed heating adopted at the Central Works, the feed water enters the boiler at a temperature a very few degrees below that of the steam itself. If the old type of rectangular boiler and the modern cylindrical boiler were to be compared, any advantage possessed by the former would be found to lie in the fact that its rectangular shape allowed of a more roomy fire grate and combustion chamber, thus allowing the gases to combine and undergo combustion more freely and thoroughly. The old shape also allowed a more roomy steam space in the shell itself. Mr. Brown had surely not forgotten that pressures had been increased during the last twenty to twenty-five years to about five times what were in vogue formerly, and consequently carried with them a corresponding increase in efficiency. In connection with the question of higher pressures, it might be mentioned in passing that the boilers referred to as fitted in the "Inch" line of steamers the working pressure was ultimately fixed much lower than had been the

original intention. Three hundred pounds per square inch was aimed at, but this pressure was found to be impracticable, owing to the nature of the rules and requirements affecting boiler shells imposed by some of the registration societies. What had really been at the bottom of many failures of high pressure boilers was the presence of air in the feed water, and one of the first steps in the treatment of the feed in the above steamers was the elimination of this air early in the stage of pumping the water into the boilers. This was effected by passing the feed through what is known as a contact heater, in which the water meets a body of steam and mingles freely with it ; the temperature is thus raised, and the air at the same time dissociated from the water. The gain in efficiency is at least 6 or 7 per cent., and may easily be 10 per cent. As showing how the great waste referred to by Mr. Brown has been met in the most recent practice, the following table will give :—

	Degs. Fahr.
Temperature of feed water in hotwell	96
,, at inlet to contact heater	113
,, at outlet from contact heater and inlet to surface heater	200 to 212
Temperature at outlet from surface heater and before entering boilers	370 to 400
Temperature, air of atmosphere	53
,, entering furnaces	300
,, waste gases below superheater	620
,, waste gases above superheater	543
,, waste gases above heating tubes	400
,, waste gases at funnel	310
,, of steam in boilers	412
,, of steam in superheater	470

It will be noticed that as much as possible has been taken out of the heat before ejecting it into the funnel, in fact it leaves the fan at practically the same temperature as it enters the furnaces. These results were obtained on an extended trial between Hartlepool and Dover, with ordinary and fair attention given to feeding, stoking and draught, and fully justify the anticipations of both owners and builders. Where such installations fail is in the want of attention given them under ordinary conditions at sea, and in this respect perhaps no department requires more careful attention than the stokehold. It is a pity that so much should depend upon the ordinary stoker with his slice and shovel, and that, hitherto, mechanical means of stoking have been almost a failure. Any one can easily throw coals on a fire, but it takes long practice and pains to appreciate the real object of stoking, namely, the economy of fuel. The fires should be of such a thickness as is suitable for the kind

of coal used. Different coals require different quantities of air for their complete combustion, and what would constitute a suitable draught for one coal might be quite unsuitable for another.

Again, if too much fuel be thrown on at once, it frequently happens that insufficient air is admitted for the combustion of the large volume of gases suddenly produced, and there is a consequent fall in the temperature of the furnaces, which may reach such a point as to prevent combustion at the proper moment altogether, and so be a source of loss because of the heat required to be drawn from the fire to insure their liberation. It is because of this that an artificial draught, properly regulated, tends to economy, which would be further increased if some device for regular and uniform stoking could be introduced Mr. Brown leads up very ingeniously to the subject of retarders, which he has made a specialty of lately. The fitting of retarders is too often a matter of guess work, and it has been found in several instances that if a little attention had been given to the design of the boiler with respect to the fuel to be used in the first instance, so much "retarding" need not have been resorted to. In cases where the fuel is of a cokey nature there should be ample provision made to enable the hydrocarbon and carbonic oxide to be burned in the combustion chamber. This would allow of the tubes being made of a much smaller diameter, and thus add proportionately to the heating surface, and so allow the hot gases greater play in raising steam. The evaporative efficiency would thus be increased, as this depends on the proportion of coal burned to the heating surface provided to transmit the heat generated to the water. On the other hand to procure to the full the steam producing power of long flaming coal, large diameter tubes are required, so that the flame may pass easily through them. It had been the experience of the speaker in connection with retarders that both spiral and Scott's had to be arranged to suit the nature of the fuel used. In some instances their removal altogether from the boiler had been necessary; in others they had to be replaced so as to insure economy. It cannot be said they are good, bad, or otherwise apart from the conditions under which they are used. Where some such fitting is necessary they are good, where they are not required they are decidedly in the way if fitted.

Mr. STEPHEN HODGSON (by invitation) said he had not had the privilege of reading the paper, otherwise he would have been very pleased to have made some remarks upon the efficiency, or attempts to increase the efficiency of the boilers, at the invitation of the Chairman. With

regard to superheating the steam, there could be no doubt that increased efficiency resulted therefrom; but, in his opinion, they had about reached the limit in this direction. In superheating the steam it was deprived of a certain amount of moisture, which otherwise acted as a natural lubricant. This caused the working parts to run drier, thus increasing the friction, destroying the packing, cutting the cylinder and valve faces, and scoring the rod. This to a certain extent was met by lubrication; but, here again, they were met with the difficulty which was experienced over twenty years ago, in not having a sufficiently good, reliable lubricant, capable of withstanding the high dry temperature without carbonising, and thus itself becoming a source of danger. Experiments were needed to test the efficiency of packing and lubricants before proceeding to a higher degree of superheat than 460 degs. Fahr. at present in use; otherwise there was a great danger of the rod "firing" or "seizing," and a smash up in the high pressure cylinder.

Here, the efficiency of the engine seemed to put a limit to the efficiency of the boiler, so far as the degree of superheat was concerned, and they could not very well dissociate one from the other, as it was the "combined efficiency" of engines and boilers that engineers were most concerned with. But although these practical considerations pointed to a temporary limit to the degree of superheat that could be safely used with a reciprocating engine, he found that it was otherwise with superheated steam in "turbo-motors;" as he had read, that, "in a recent issue of *Science*, Professor Thurston had called attention to an unexpected economy attending the use of superheated steam in turbo-motors, which had been revealed in the course of some experimental investigations that had been made in the laboratories of the Sibly College. The main source of economy in the ordinary reciprocating engine when using superheated steam, arose, as was well-known, from the prevention of the waste known as 'initial' or 'cylinder' condensation, which occurred when saturated steam was used, as a consequence of the large fluctuations of temperature which accompanied the variations of pressure within the cylinder. In the steam turbine initial or cylinder condensation did not occur, inasmuch as the interior surfaces in steady working remained at practically the same temperatures, and hence it might be thought that any gain resulting from the use of superheated steam could only amount at most to the increase of thermo-dynamic efficiency corresponding to the increased range of temperature, and which would be about one-tenth of 1 per cent. for each degree of superheat. The investigation at the Sibly College, however, had shown that the gain was much greater than

this, amounting, it was stated, to about 1 per cent. for each 3 degs. Fahr. of superheat, accompanied with an unexpected increase in the power capacity of the machine of about 100 per cent. by the use of 37 degs. Fahr. of superheat. The causes of the gain in thermo-dynamic efficiency and of power capacity from superheating were presumably identical, and due apparently to the extinction of the friction wastes which occurred when using saturated steam, owing to the retardation of the current by the moisture in the form of drops and mist which adhered to the walls of the steam passages, and thereby caused a considerable drag. That this explanation was probably the correct one was supported by the fact that the gain, so far as the experiments had been carried, was substantially proportional to the amount of superheat, though further experiments were being made with a view to more precisely identifying the causes and determining the laws governing their action."

So far, then, as the attempt to increase the efficiency of the boiler by obtaining a high degree of superheat was concerned, there seemed at present to be a better opening for its successful use with the turbo-motor than the reciprocating engine. But here, again, he anticipated a "limit," as it remained to be seen what effect the use of a very high degree of superheat would have upon the vanes, steam passages, etc.

The following communications were received by the Secretary :—

12, Clydeview, Partick, Glasgow,
March 1st, 1901.

Dear Mr. Duckitt,

Mr. Brown's paper is an interesting one and should lead to a good discussion.

I have tried to think how the boiler built in the sixties can be compared with the boiler of to-day, but I must confess I am unable to do so. To my mind they are so entirely different in proportions and methods of construction that beyond an outward similarity all comparison ceases.

The 20 per cent. loss mentioned looks bad, but if the loss owing to radiation, a loss impossible to prevent, even in well protected boilers, is taken into account this figure will be reduced by about 5 per cent. If it were possible to get firemen who thoroughly understood the principles of perfect combustion and the means to be taken to promote it, the remaining 15 per cent. would be considerably reduced. Most marine

boilers constructed in this country are adapted for the use of British coal, but when the poorer qualities of foreign coal are used, anything but a good result is obtained.

Mr. Brown mentions Mr. Audenet's experiments, some of which I had the pleasure of carrying out under his direction. The attempt to reduce the temperature of the gases by passing them through the tubes three times was well thought out and proved a distinct success theoretically.

The result of the sea trials of the Audenet system showed a saving of 20 per cent. over that obtained with similar boilers under natural draught in a sister ship, and a slightly increased power was obtained. As Mr. Daymard remarks in his paper on "Forced Draught," communicated to L'Association Technique Maritime, "such a result is sufficiently tempting to induce its adoption elsewhere, but unfortunately in practice the system is impossible owing to the difficulty in cleaning the tubes and keeping the divisions in the fire and smoke-boxes in good order and the smoke-box doors from getting red hot." Had the boilers with which these experiments were made been originally designed to meet Mr. Audenet's views, I have no doubt that a good many of the troubles met with would not have cropped up.

Uptake feed heaters were just as successful in showing a saving as the Audenet system was, but they too were found wanting in practice; and it would appear as if they are not going to be any greater success with water-tube boilers. If these heaters are not going to prove a success, seeing that every care is taken to eliminate all corrosive matters from the feed water, there is small chance of their being used. Economy purchased at the expense of a heavy bill for repairs is no economy at all.

The shipowner wants a boiler that is reliable and which is easy to keep up, and I think it must be conceded that he has it in the present type.

Yours faithfully,

A. E. SHUTE.

113, WITHINGTON ROAD, MANCHESTER,

2nd March, 1901.

DEAR MR. DUCKITT,

I regret that an unusual pressure of business has prevented me from earlier committing to writing my thoughts on the subject of Mr. Brown's suggestive paper, which reached me a fortnight ago.

In discussing this subject it is advisable at the outset to point out precisely what is meant by the *efficiency* of a boiler, and on what it

depends. The efficiency of a boiler, then, of whatever kind, is defined as the ratio of the heat transmitted to the water to the total quantity of heat that would be yielded by the perfect combustion of the fuel. Its value ranges from 60 to 70 per cent. as a rule, and may exceptionally reach 85 per cent. Practically, the efficiency of a *steam* boiler is measured by dividing the number of pounds of water evaporated per pound of fuel by the theoretical evaporative power of that fuel, as determined by means of a calorimeter. Thus the efficiency of a boiler depends both on the degree of completeness of the combustion and on the facility with which the heat generated is transmitted to the water. In fact, the efficiency of a boiler is the product of the efficiency of *combustion* (or ratio of heat generated to calorific value of fuel), and the efficiency of the *heating surface*, *i.e.*, the ratio of heat passed into the water to the heat generated.

Accordingly, the methods of increasing the efficiency of a boiler resolve themselves into two groups, viz. :—

a. Those which aim at increasing the thoroughness of the combustion of the fuel.

b. Those directed towards improving the effectiveness of the heating surface in absorbing the heat generated.

Methods of promoting better combustion are the following :—

1. *Improved stoking*, so as to produce a fire of nearly uniform thickness over the whole grate. The golden rule for the avoidance of smoke is "fire lightly, fire quickly, and fire often."

2. To use a *small grate area* compared with the heating surface; which means short grates, but *not* small diameters of furnaces.

3. To have large or *roomy* furnaces and combustion chambers, to provide room for the expansion of the gases. Of recent years the tendency has been to enlarge the combustion chambers of boilers, even with the loss of a certain amount of tube-heating surface, experience having shown that this increases their economical performance. Locomotive fire-boxes have also greatly increased in size. The comparative inefficiency of water-tube boilers without economisers is probably partly due to the absence of a sufficiently large combustion space.

4. To diminish the amount of excess air passing through the furnaces, by the employment of artificial draught; thus keeping up the temperature of combustion. Too little air, however, is worse than too much, owing to the production of carbon monoxide.

5. To heat the air required for combustion, as in Howden's system and in that of Ellis and Eaves.

6. To plug up the upper rows of tubes so as to compel the hot gases to take a longer path before entering the tubes, thus enabling them to intermingle better, and rendering their combustion more nearly perfect.

Methods of utilizing to the utmost the heat generated may be enumerated as follows :—

1. The revival of feed heaters or economisers to reduce the temperature of the chimney gases.

2. The lengthening of the boiler tubes.

3. The superheating, by the waste gases, of the steam on its way from the boiler to the engine. It seems to me that such an amount of superheating as will serve to completely remove all water in suspension is probably all that it is wise to attempt in practice. To attempt more is to court trouble with cylinders, piston rods and valves ; except, perhaps, with very specially designed single-acting engines, such as those of the Schmidt type.

4. To increase the heat absorbing surface of the boiler by the use of *conductor pins* or by projecting ribs, as in the Serve tube. This method seems to be very effective so long as the surfaces remain clean, but is there not considerable difficulty in keeping such surfaces free from deposit, and are not Serve tubes very heavy ? I understand that the Serve tube is gradually coming into use for locomotive boilers, but that they get made up much sooner than plain tubes. Mr. Fletcher has successfully used conductor pins in the case of gas-fired boilers.

5. The use of *spiral retarders*, or strips of twisted plate, to break up the stream of hot gas through each tube, and so compel more of the particles to come into intimate contact with the absorbing surfaces. An objection to this method, as Mr. Brown points out, is that a very strong draught is necessary to prevent the accumulation of ash and soot. I believe, though, that Mr. Howden uses them with success in boilers fitted with his forced draught system.

I have taken the trouble to thus classify into two groups the various methods of increasing the efficiency of boilers referred to by Mr. Brown, because it seems to me to be both interesting and scientifically important to clearly discriminate between the two distinct principles involved therein. In the paper, Mr. Brown has preferred to follow the historical or chronological order of the introduction of these methods.

In a good cylindrical marine boiler, supplied with sufficient air and burning about 20 lbs. of coal per hour per square foot of grate, the approximate distribution of heat, as given by Sennett and Oram, is as follows :—

	Per cent.
Heat absorbed by feed water, or efficiency	68
Heat wasted in funnel gases	24
Wasted by unburnt carbon in ashes	2
Wasted by imperfect combustion	0
Balance accounted for by radiation, etc.	6
	100

Thus there is ample scope for reducing the funnel gas waste. The accuracy of the fourth item seems open to question.

The remarkably high efficiency of 88·2 per cent. recorded in the Newcastle experiments was probably due to four causes, viz.:—(1) skilful firing; (2) excellent combustion, promoted by large furnaces; (3) small radiation loss, the temperature of the steam being only 212 degs. Fahr.; and (4) the use of a feed heater at the base of the chimney.

The comparatively low efficiency of high-pressure cylindrical boilers is due partly to increased radiation loss and partly to the form of the furnace, the latter being the more important of the two. As Sennett and Oram remark:—"In the low-pressure boilers, with furnaces of nearly rectangular form, the necessary distance above and below the fire-bars could generally be obtained whatever the width of the furnace might be. But in the high-pressure boilers, in which the furnaces are cylindrical, the height above and the depth below the bars are dependent on the diameter of the furnace, and it is difficult to keep the crown of the furnace sufficiently high above the fires, or to make the ashpit high enough to allow an ample supply of air to the fires. The smaller their diameter, and the greater their length, the greater is the difficulty of securing a proper measure of efficiency."

Another feature which tends to reduce the efficiency of cylindrical boilers is the restricted area of water surface, and the relatively small volume of the steam space, which make them more liable to prime.

Early in the paper it is stated that "a fairly rapid rate of combustion gives the best results, provided the grate area is not large;" but the grate area relatively to the heating surface, seems to be a more important factor. To substantiate this statement I have tabulated some of the experimental results alluded to, showing the influence of the rate of combustion and grate area on evaporative efficiency:—

Grate area, in square feet.	Combustion per square foot of grate.	Evaporation per lb. of coal.
	Lbs. of coal.	Lbs. of water.
42	17·24	9·25
28·5	19	11·13
22	17·27	11·7
19·25	17·25	12·53
18	18·67	11·17

Thus the evaporative efficiency was increased about 28 per cent. when the grate area was reduced to less than one-half.

Mr. Brown remarks that "no complete measurements of the temperatures and pressures of the products of combustion, as they pass from the furnace to the chimney, have ever been made." Probably this is true, as such measurements are not easily made. But, on p. 41 of Sennett and Oram's *Marine Steam Engine*, there is an interesting diagram showing the distribution of temperature inside a marine boiler tested at Devonport. The temperature at the centre of the combustion chamber is given as 1,576 degs. Fahr., and at the centre of the smoke-box 740 degs. Fahr. The pressures of the gases, however, are not stated.

Reference has been made in the paper to the abandonment of feed-water heaters utilising the heat of the chimney gases, in the case of ordinary marine boilers. In this respect large stationary power-plants compare favourably with marine practice. Now-a-days no generating station of any importance is ever destitute of its set of economisers, of the Green, Calvert, or other type; and chimney temperatures exceeding 400 degs. Fahr. are unusual. But, of course, feed heaters of the Green type are extremely heavy and cumbrous, so that their use on shipboard is quite out of the question. Still, by employing steel or brass tubing, instead of cast iron, and by giving the water a comparatively high velocity, it should be possible to design a suitable flue-gas feed-heater, instead of relying entirely upon low-pressure steam-heaters. In the old feed-heaters referred to by Mr. Brown, the hot gases passed through vertical tubes, and the feed water surrounded them. In this way the need for automatic scrapers was avoided. Apparently the scouring action of the gases was sufficient to keep clean the interior of the tubes, without special provision for either frequent or continuous cleaning. One cannot but admire the boldness and persistence of Mr. Ebenezer Kemp, in his various attempts to devise a successful economiser for marine work.

All recent boilers of the Belleville type are fitted with economisers, through which the feed-water passes and absorbs heat before entering the steam collector. The economiser has $2\frac{3}{4}$-inch tubes, and is placed in the uptake, about 4 or 5 feet above the top tube of the generator or boiler proper, which has $4\frac{1}{2}$-inch tubes. The space between the generator and the economiser acts as a combustion chamber, in which any unconsumed gases are furnished with additional air to assist their combustion, and given room to expand, before traversing the spaces between the economiser tubes. With this modified type of Belleville

boiler excellent efficiencies have been obtained. Mr. H. J. Oram gives the following results of trials made by Admiralty officers on such a boiler erected on shore. Good Welsh hand-picked coal was used, and a large separator was fitted to ascertain if any water was carried over with the steam :—

EVAPORATION TRIALS OF BELLEVILLE BOILER WITH ECONOMISERS.

Coal burnt per sq. ft. of grate, in lbs. per hour ...	18·5	24·5	31	37
Ratio of heating surface in generator to grate ...	21	21	21	21
Ratio of heating surface in economiser to grate ..	11·7	11·7	11·7	11·7
Ratio of total heating surface to grate	32·7	32·7	32·7	32·7
Duration of trial, in hours	8	8	4	4
Actual evaporation of water into lbs. of dry steam per lb. of coal	9·94	9·62	9·33	9·17
Equivalent evaporation from and at 212° F. ..	12	11·6	11·2	11
Actual evaporation of water into dry steam, in lbs. per sq. ft. of total heating surface	5·63	7·23	8·84	10·4
Steam produced, in lbs. per sq. ft. of grate ...	183·9	235·7	289·2	339·3
Temperature of feed water, F.	68°	68°	68°	68°
Temperature of feed leaving economiser, F. ...	226°	250°	300°	330°
Steam pressure in boiler, lbs per sq. in.	205	215	220	230
Temperature at base of funnel	394°	518°	650°	750°
Temperature between generator and economiser ..	860°	1112°	1300°	1560°
Fall of temperature of gases in passing through economiser	466°	594°	750°	810°
Vacuum at base of funnel, in inches of water ...	·46	·62	·8	1·12

It will be noticed that the value of the economiser rapidly rises as the rate of combustion is increased. As the evaporative power of 1 lb. of Welsh coal is $1400 \div 966 = 14{\cdot}5$ lbs., the highest efficiency of the above boiler is 83 per cent. and the lowest 76 per cent.

Experience shows that the one great drawback to the use of such economisers is their want of durability.

In a paper recently read before the Manchester Association of Engineers, Dr. J. T. Nicholson suggests that a wider meaning should be given to the word *economy* when applied to a boiler than that which refers merely to the saving of fuel. That boiler is the most truly economical which gives the most steam at the least *total* expense, allowing for interest and depreciation on first cost of boiler and housing, together with the running expenses and the cost of maintenance. After summing up all the items of cost and dividing by the weight of steam generated per year (or by the number of heat units in that steam), we get the *actual cost* to the boiler user of the steam generated.

Thus it may happen in some cases that boilers comparatively wasteful in fuel, or thermally inefficient, may be the most truly economical in the long run. It depends on the number of hours per year the boilers are worked. The boilers of warships, for example, give the most steam

per pound sterling invested and spent when they are of relatively small first cost, and capable of being forced up to a rate of evaporation higher than that corresponding to the best thermal efficiency. The same is true of the entire power plant of electric lighting stations, such plant being either idle or under-loaded for the greater part of its life.

Dr. Nicholson points out that it is a great advantage to increase the speed of circulation of the water on one side of the heating surface, and the frictional resistance to the flow of the hot gases (as by the use of retarders) on the other. When the circulation is sluggish inside the boiler, a badly conducting film of water (or possibly steam) adheres to the hot surface, and may permit of a difference of temperature of many degrees existing between that surface and the main body of the water. Further, if the hot gases do not *scrub* sufficiently against the inner heating surface, that surface may remain at a temperature hundreds of degrees below the temperature of these hot gases; with a cold film of non-conducting gas adhering to it, and retarding the passage of heat to a much greater extent than almost any possible thickness of iron or copper plate. Hence, if we could have a very much more rapid circulation of both the water and the hot gases over our heating surfaces, the latter might be much reduced; and a much cheaper and hardly less efficient boiler would result.

There is one item in Mr. Brown's paper I can't understand. On page 110 it is stated that with 70·5 revolutions per minute the time of passage is 12 hours 20 minutes, while with 69·2 revolutions per minute the time is reduced to 12 hours 12½ minutes. How does it come about that with fewer revolutions the time occupied is less? Was the course shorter or the propeller different?

In conclusion I have to thank Mr. Brown for an interesting and suggestive paper, written in the true scientific spirit, on a most important and somewhat neglected subject. He has certainly made out a good case for the use of retarders of some form in multitubular boilers.

Yours faithfully,

W. H. ATHERTON.

The discussion was adjourned.

SOME REMARKS ON THE COMMERCIAL ORGANISATION OF SHIPYARDS.

By WALTER SCOTT.

[Read before the Institution in West Hartlepool, on March 2nd, 1901.]

When asked by the Secretary to read a paper before the members of this Institution, the writer's thoughts at once reverted to the excellent paper on "Works' Organisation" read by Mr. Tom Westgarth some little time ago. The views opened up by that paper, and the interest taken by members in the discussion, caused him to think that some remarks on the commercial organisation of shipyards might be of general interest.

The importance of most efficient organisation in this respect will, no doubt, be generally admitted. The keen competition of the present day is such that there is often a very narrow margin between profit and loss, and a slight miscalculation, or an omission to give due consideration to any of the various factors affecting, or likely to affect, the cost of such a large thing as a modern vessel, may easily cause the balance to be on the wrong side. A shipyard or an engine works may be equipped with the most modern plant, may have a highly trained technical staff, and first class foremen, but unless the commercial department is thoroughly efficient, and organised in such a manner that the controlling head can easily, carefully, and quickly grasp the relative value of the various points, without having to spend time on details, it is impossible for the business to be the success it should be.

Much of the information given may not be novel, but it may be useful to the younger members of the institution, and, in any case, the writer trusts may induce an interesting discussion. The subject is divided under several headings, and dealt with in their natural order.

We will assume that the reader is about to take up a new position as managing director, general manager, or as principal or commercial partner in a new firm, one of the first things which will engage his attention is

Correspondence.

It will be found advantageous to make it a rule for all incoming correspondence to pass through the principal's own hands sooner or later. If it is a small business he is controlling, this is very simple ; and, if it is a large one, his secretary will, of course, open all letters except such as are marked private, and sort them according to their contents, they can then be quickly glanced through, and their contents noted, etc. By a little arrangement it is surprising how quickly a large correspondence can be got through efficiently. A good practice is to stamp each letter with a rubber stamp as it is considered. (See Table I.) This gives

Table I.

Seen. 12th Feb. 1901.
Acknowledged.....
Instructions.....
Answered.....
Docket .....

the date when the stamp is affixed, and, consequently, when the letter is seen, and the blank spaces are used for instructions as to what is to be done with it. After it has been finally answered, the initials of the responsible head should be affixed in the blank space marked "docket," after which it may be put away (but not before), for reference, being filed by one of the various excellent systems now coming into more general use. A system based on a similar principle may be adopted, no matter how large the correspondence to be dealt with. The following principal points should be kept in view :—

(*a*) All letters must be answered, or at least acknowledged the same day as received.

(*b*) No original letter should be handed to managers, foremen, etc., unless in very exceptional cases, when a note of it should be kept, but extracts therefrom, or a typewritten copy should be issued instead.

(*c*) No original letter should, on any account, be docketed until completely dealt with, but should come up for consideration, day by day (after the day's letters have been gone over), until it can be finally disposed of. The writer knows of no more salutary check on dilatoriness or carelessness on the part of subordinates.

(*d*) Confirm at once in writing all telegrams and important telephone communications

In answering correspondence, the principal will, of course, use his discretion as to what letters he answers himself; the majority can be dealt with by the secretary, but it is better, for obvious reasons, that the principal should deal with all important letters himself, as far as his time will admit. A good shorthand clerk will reduce the labour and the time occupied to a minimum, and, of course, a typewriter will be employed.

The writer would strongly recommend young members to practice the art of dictating, say letters or specifications, as it is an acquirement easily attained, and even if the reader never comes into a position where its use is required, it is an excellent mental training in the way of giving disjointed ideas on any subject, a concrete shape.

We now come to the question of

Estimating.

This is a subject of vital importance, especially when it is necessary to compete in the open market for work, the crux of the matter is, one must be able to form beforehand a close estimate of what the work will cost under normal conditions, then, with this as a basis, there is play for business abilities, for judgment, or knowledge of the market, and of the customer. An estimate for a vessel is a complex subject, and a small mistake may amount to a large sum. A most fruitful source of error is the omission of something. Printed estimating sheets should therefore be used, and these sheets should be thoroughly detailed, but, the details should all be grouped, so that the approximate cost of a vessel based on main headings may be quickly made up, for it is sometimes necessary to send an estimate by the same night's post, or even reply by wire. Table II., gives a portion of one of these sheets dealing with the iron work only, but all other items can be arranged on similar lines, including wages, which should form an item to themselves. Do not base an estimate on a previous one, but work rather from prime cost, or a previous error of judgment or of calculation may be repeated, but, of course, previous estimates may be used as a check. Before one can estimate for or successfully build a vessel, one must have a knowledge of the market prices of materials and purchase the same. This brings us to the subject of

Buying.

It will probably be found both convenient and profitable to make yearly or half-yearly contracts for certain things, such as paints, rivets, ropes, bolts and nuts, rubber goods, and generally such things as are

made up of a multitude of small items which are required in varying quantities throughout the period proposed to be contracted for. Material such as steel, iron, and wood, will probably be purchased in quantities; and in trying to contract ahead on a rising market, or avoid doing so when it is falling, there will be found plenty of scope for business acumen, but beware of gambling and reckless speculation in this matter. Several competitive tenders for the various requirements, as far as possible,

TABLE II.

.....Cost of...			Date, ...
For.....			Ref. No. .....
Cubic No. ..... Sq. No. ..... D.W. Capability.			
MATERIAL, basis rate. Bars, £ ..... Plates, £.....			
Forgings, *ex* Keel.			
Keel Bars.			
Bars.			
Plates.			
Smithy Iron and Steel.			
Rivets (*Coef*.....)			
Castings.			
Service Bolts and Screws.			
Total Invoice Weight, ...			
WAGES on rates of..... , and plus or minus.....% to date—			
Iron Builders.....per ton invoice Weight.....%			
Carpenters.	*Coef*.....		
Joiners.	*Coef*.....		
Blacksmiths.	*Coef*.....		
Engineers and Finishers.			
Painters.	*Coef*.....		
Furnace, Engine, and Machinery Attendants.			
Storekeeper, Gatehouse, &c.			
Plumber.			
Cementers.	*Ceof*.....		
Riggers.			
	Total Wages,		

should be obtained, and their acceptance, or otherwise, be decided by the principal himself or the reliable departmental head, this will give him a salutary check on any attempt at secret commissions, a not unknown thing, though the majority of firms in this country are, fortunately, free from this taint. Avoid asking tenders unnecessarily, and, after due consideration and decision, make a point of advising the tenderers of their

success or otherwise. If the reader wishes to purchase in the best markets, he must prevent it being thought that a certain firm has "got in" with him, and that it is, therefore, useless tendering; on the other hand, if he is well served, it is very unwise to make a change for a small advantage, and he should remember there is the question of quality to consider, and also the important one of promptness and regularity in delivery, for laxity on this last point may seriously dislocate the business, and enormously increase the cost of construction. The point next in importance is

Cost Keeping.

To do this item justice, a separate and detailed paper should be given to it alone, and the writer can therefore to-night only deal with it generally. All the costs should be kept in grouped detail, and arranged in precisely the same order as the estimate sheets; they must not on any account be allowed to run into arrears. In a well organised office it should be possible to see the cost of any vessel to date at least each month, or even each fortnight, and that, too, at a period only two or three days after the date the cost is made up to. This is not a difficult matter, neither does it necessarily involve a very large staff, whilst its importance is paramount, both for estimating purposes and as a check on the cost of construction. An important matter in cost keeping is the allocation of general charges, such as salaries of staff and foremen, depreciation of buildings, machinery, plant, cost of lighting, etc. The writer is afraid that the item of works charges or establishment charges, as it is sometimes called, is a very elastic one. The following details should, he thinks, constitute this item only:—

Salaries of managers, technical and commercial staffs, foremen or other non-producers.

Postages, telegrams, stationery, and telephone rent.

Gas or lighting expenses of offices, but not of ships or yard.

Advertising.

General travelling or other similar expenses, and which cannot be charged to any special job.

The following items are better kept separate:—

1.—Rent, rates and taxes. *Note.*—In case of repairing establishments owning slipways or dry docks, it is a good plan to place any dock dues received to the credit of rent and taxes account.

2.—Depreciation of buildings, machinery, and plant.

3.—Upkeep of machinery and plant.

4.—Gas, oil, and lighting (electric or otherwise) of workshops and yard, but excluding offices.

5.—Coal or other material for ironbuilders or other furnaces, including that for boilers and rivet fires.

6.—Smithy coal, etc.

The relative value of all these items should be fixed every three months at the time the quarterly balance is made, and a co-efficient for each obtained. There are several methods of allocating the proportion fairly chargeable to each job, but the following will be found generally efficient and easily worked, viz. :—

Establishment charges—charged to each ship in proportion to the wages paid.

Rents, rates, etc.—in proportion to tonnage of vessel, or a figure equivalent to same, such as $\frac{L \times B \times D}{100}$ and commonly known as the cubic number.

Depreciation, etc.—in proportion to wages paid, this may be made up of two items, viz., ironbuilders and woodworkers, if thought desirable.

Gas, oil, etc.—in proportion to wages paid, but corrected for time of year.

Coal, etc.—in proportion to number of tons of steel or iron worked into ship.

Smithy coal—in proportion to number of tons weight of smith work turned out.

All wages cost should be divided up so as to show the amount expended on any one job by each separate trade, piece work and time labour being kept separate. The system of piece work is of great help in keeping these costs. Returns of this should be made every week, say not later than two days after wages pay day; these need not be too detailed, but may be grouped. It is a good plan to have these returns plotted so as to show the results graphically as a rough curve. This enables a far better all-round opinion to be formed as to progress or otherwise, than a mass of figures can possibly do. Similar returns should be made each week (and plotted in like manner) for such items as coal consumed, gas or coal consumpt, amount expended on repairs and upkeep of buildings, machinery, and upkeep of wood tools, such as uprights, blocks, etc., which is a very expensive item, especially in repairing establishments—and other items of like nature. The costs of alterations or extra work on a vessel should always be kept separate from the original contract,

and for this purpose it is better to issue as required separate or special orders in duplicate to the foremen of each trade concerned. They can be given a consecutive number. Similar orders should be issued for all work in connection with repairs of buildings and tools, fitting up of new machinery, etc., so that the account to which it is to be charged can be easily adjusted in the office, otherwise it may turn out that certain work has been charged to capital account which should have gone to maintenance or upkeep, and so on. This enables an easy check on expenditure to be kept, and all orders should be initialled by the responsible head at the earliest possible moment and preferably before the work is commenced; but of course under-managers will be allowed varying amounts of discretion, according to their position or ability, so as to prevent any deadlock. The principal's object should be, while keeping in close touch, to avoid too much centralisation, or he will be worried with details, and his time too much taken up to enable him to give the important points of the business the attention it requires. At the same time close touch must be kept, or serious leakages will soon occur. In arranging the method of cost-keeping it should, for obvious reasons, be done so that the final summarising can be completed by the principal himself, or some one whom he can trust. The charging of material from stock, such as wood, steel, rivets, etc., and the items from stores, such as ironmongery, etc., must be carefully done, two rough store journals for alternate days being kept by each store keeper for this purpose, and no stores or material must be issued to workmen except on production of a written order from their respective foremen, which order is filed and serves as a check on the correctness of the entries for the day. A point sometimes overlooked is the case of goods bought for a special ship and not all used owing to changes or alterations. These should be handed into stock and debited against same, the ship being credited. It is surprising in a large place how items of this kind will accumulate and lie in stock, until out of date and comparatively useless; it is therefore a good plan to keep a separate note of these, and let, say, the leading draughtsman keep it before him. Material or articles so left over can often be worked into a new design if not lost sight of, and considerable money saved to the firm.

Of importance in connection with cost-keeping is

Book-keeping.

The system of double entry will, of course, be adopted but possibly modified to suit the special requirements. The principal impersonal account, viz., trade account, should be kept in a special or trade ledger,

being split up therein into separate headings for forgings, steel bars or plates, rivets, smithwork, wood, paints and oils, ironmongery, ropes and sails, brass work, scrap, etc., etc., each of these are debited from the various invoice books and credited from the day books with the items put into stock or taken therefrom, and when stock is taken at the end of the financial year, theoretically it should agree with the balance standing to the credit of each account in the trade ledger, practically it never does, take for instance, steel bars and plates, these for practical reasons and to minimise handling are usually charged from stock by measurement only, the weight being calculated, but owing to discrepancies in thickness, etc., it may be that through an accumulation of small errors the actual stock turns out more or less than the ledger account shows it should be. In charging this material against different jobs it is advisable therefore to add a small percentage to the weight, this percentage should be so adjusted as to leave the actual stock when taken in excess of the amount shown in the books, and the amount of excess thus appearing at the end of the financial year can then easily be credited to the various jobs in hand during the period. The advantage of this is that all the current costs are, if anything, slightly full, and keep the estimates on the right side—an addition of 2 to 3 per cent. will be sufficient in the case of iron and steel.

A similar system should be adopted with the wood account, but the percentage must be much higher so as to cover wastage due to sawing, etc. It should be mentioned here that the wood account is one in which considerable leakage may occur, principally due to wasteful usage which may be either wilful or through carelessness. It is therefore advisable to place the wood under the control of an experienced special man, and have it stored so that wood cannot possibly be obtained except by being issued by him, in response to written orders from the foremen of the trades requiring it.

Other accounts such as rivets, bolts and screws, ironmongery, brass, paints, etc., can be kept with considerable accuracy if properly done. The writer is of opinion that it is advisable to take stock of the ironmongery department oftener than once in each year, and it is highly essential that a trustworthy and experienced storekeeper be placed in charge of this department. In some yards it is usual to keep the ironmongery exactly the same as in a retail shop, *i.e.*, price each article when handed in and charge it out accordingly—the writer, however, is of opinion that it is better to give each item a standard price and increase or decrease this, say each six months when contracts are made, or if not buying at regular

periods, on account of a rapidly fluctuating market, the difference between the store price and the actual can easily be adjusted by means of a percentage in the office books when charging against the ship, the advantage of this is that when stock is taken there is a quick and immediate check in money as to the care exercised in keeping this department, and it should be mentioned here that it is a department in which leakages may easily occur and continue for a long period without being discovered.

The methods adopted of dealing with the accounts already mentioned will indicate the principles to be adopted with the remainder, so nothing further need be said on this head. The wages book, wages abstract book, etc., should all be kept so as not only to show all the wages due and paid to each person, but so as to easily show the amount paid to each trade and to each job; the piece and time work being kept separate; and the arrangement should be such as to admit of returns being made up for inspection immediately after each pay day. These wages returns are practically the barometer of a large business, and should be carefully considered. Be sure and have all wages of non-producers kept separate, especially such as machinery attendants, storemen, sundry labourers, etc., for it is surprising, in a large place, how the number of these may grow unless a careful check is kept of wages paid under this head. The remainder of the books call for no special comment, as the ordinary rules of book-keeping apply.

The writer would like just to add a word, however, on balancing and stocktaking. It is advisable that the stock should be taken with the greatest possible care, and should, if possible, be checked by independent persons, as it is, of course, the test on the accuracy of the cost-keeping during the year. The question of expenditure on works and upkeep account must also be carefully considered, as to what should be charged to capital account and what to revenue. Generally speaking, any repairs to machinery and plant by which new parts are added, and the value of the plant increased accordingly, should be charged to the capital account; but the golden rule should be, on a question of any doubt, charge it to revenue. The question of depreciation, and amount allowed for this, is one on which there is considerable difference of opinion. It is usually allowed in the shape of an overhead percentage varying from five per cent. upwards, according to individual or special circumstances, and this percentage is often supposed to give the necessary reserve for the renewal of obsolete, though not worn out tools, by more modern ones. The writer is of opinion that it is well to charge for actual wear and tear

depreciation, an overhead percentage of say five, six, or seven per cent., together with the addition of a special percentage in cases of certain tools thought to require it; this latter can easily be allocated if the value of each machine or tool is kept separate in the inventory book, as it should be. In the case of the plant in wood tools, viz., uprights, staging, blocks, etc., it is better that they should be measured and revalued each year, especially in a repairing establishment, as their wastage and value is very fluctuating. The allowance for substitution of new plant, or tools for obsolete ones, is better kept separate, a certain sum being put on one side to this account each year; and, when an old machine is done away with, its current value is debited against this account, as well as the cost of the new machine which replaces it. Unless the revenue of a business will admit of this being done, it cannot be said that a true profit has been made, as it is imperative that a business should be kept abreast of the times. In order that the whole of the foregoing requirements may be properly attended to, it is necessary to maintain a sufficiently large and efficient

Commercial Staff.

The selection and general treatment of the commercial staff is not a subject with which the writer proposes to deal, except to mention that reasonable consideration of their comfort, feelings, obligations, etc., will be amply repaid by the better quality and amount of work done. A most important point is the arrangement of the work; this should be split up and arranged so as to make the duties, as far as possible, of a regular and routine nature. and the duty of summarising and gathering together of the main items should be done by the chief clerk. secretary, etc. The duties should also be arranged to overlap, and so minimise inconvenience from absence through sickness, etc. The principal's confidential clerk should be carefully chosen. It is advisable that he be a good shorthand writer, and have a good general knowledge of the books; also have systematic habits; and it will probably be found advantageous to give him six months in the drawing office, plotting curves, etc., before retaining him for this special service, his training will make him admirably adapted for assistant secretary later on, if necessary.

The question is often asked: "Is a large staff necessary or the reverse?" The writer is of the opinion that a large staff is, generally speaking, not necessary: it is, however, a question very difficult to generalize upon, and must be largely decided by the special requirements of the individual firms concerned. There is no doubt that the staff as a whole must be

efficient, and deficiency in the number employed must not be allowed to imperil that efficiency. In the technical staff the writer believes that a moderately small staff composed of members of good experience and abilities with one or two routine members is much better than a much larger staff of more moderate qualifications, and will not only conduce to better constructional work, due to better designing, but also do the actual drawing office work both quicker and cheaper. This view, however, is not generally shared. While keeping the technical staff sufficiently large to enable fairly detailed plans to be issued for most jobs, do not permit the chief draughtsman to run to the extreme of trying to control every little detail of construction from the drawing office, such a course simply tends to convert what should be intelligently conducted duties of the foremen into most mechanical ones. The chief draughtsman also should be a man of tact and good broad general views, that is to say, he should not be chosen for his technical abilities alone. Do not pay off members of the technical staff or non-routine members of the commercial staff directly there is the least sign of a lull in trade, this is a thing many limited companies are very prone to do, but the writer is of opinion that it does not pay in the long run; but by all means use the opportunity to weed out the drones. An efficient technical man, who has got conversant with the firm's methods of work and is thoroughly in touch all round, is not easily replaced, besides it will be found that if the place gets a bad name in this respect, the rate of pay for good men will have to be raised, as the number of good technical men is not by any means inexhaustible, consequently the business suffers, probably in a way which does not readily show itself; this therefore is a subject on which it is wise not to hold too narrow views. Generally speaking, each member of the staff should be made to feel that the efficient performance of his regular duties is preparing him for the next higher step, even if these duties are only of a routine nature. A question that will require serious consideration is that of

DEVELOPMENT.

The whole of the organising arrangements should be with this in view. Make it a rule to adopt no system that is not capable of easy expansion: this is a fault that new and young firms usually make. If it is found that the existing system is not up to date, and capable of expansion, do not hesitate to change it, radically and as soon as possible. It will quickly pay, but, of course, it is not necessary to create a small revolution in doing it. All questions of fitting new plant, altering the system of working, etc., require careful consideration. It does not follow that because a

rival has completed great changes, such as, for instance, the fitting up of a large electric driving plant, that this is the best thing to do, for it is unsafe to generalize in such matters. A new system, which is intrinsically good, may, owing to local or special conditions, not pay every one to adopt; this, of course, applies the reverse way also, and it is necessary to be on the sharp look-out for occasions on which it does, so as to obtain full benefit of any local advantages. A careful manager will keep ahead of the times in his views, and, if he foresees chance of improvements coming to the front later on, will keep data calculated to show if the change, when it comes, would help or otherwise, and so aid prompt decision. The great point is not to be too narrow in considering these things, and to be cautiously enterprising.

Let us now consider the question of advertising. Of course shipbuilding is not like a business in, say, patent medicines, but at the same time judicious advertising will no doubt pay. There are so many changes nowadays, in superintendents, and others who can influence orders, not to mention new customers springing up, especially abroad, that it is advisable to keep the name of the firm constantly before the shipowning world.

The writer has now only a few general remarks to make.

Keep a standing-order book with separate entries for each department, and do not make standing orders except after due and mature consideration. Have a private diagram made of the various ramifications of the business, showing graphically how the different departments' accounts and books dovetail in with, and depend on, one another. It will be found very helpful in giving a comprehensive view when thinking of any changes, etc.

Do not centralize the business too much, but go in for what might be called departmental centralisation. Remember that a well organized business should run itself for a reasonable period in case of the enforced absence of the head.

Carefully consider the amount of discretion to be allowed departmental managers, etc., but do not forget that a check requires to be kept on this.

Keep abreast of the times, and do not be too conservative, especially in methods of work.

In conclusion the writer has only to state that his endeavour has been to give a synopsis of the various points generally to be kept in view in the commercial organisation of a shipyard, so that the younger members may see what they have before them, while at the same time the writer is hopeful that some of the older and better versed members may be induced to give their views on the different items herein dealt with.

DISCUSSION.

Mr. M. C. JAMES said he thought they were greatly indebted to Mr. Scott for his very interesting paper. The older members probably would see nothing very new in the matters dealt with in it; but, he thought the writer was to be complimented upon the way in which he had put the various points before them. It showed also that the writer must have a well ordered mind, and be possessed of very considerable general experience in the commercial conduct of shipyard and repairing business. He (Mr. James) had not had much time to go through the paper, but there were one or two points he should like to comment on. First, in regard to the correspondence. He personally agreed with the method which Mr. Scott adopted, and with one thing particularly, the confirmation of telephonic communications. The use of the telephone had extended very much in recent years, and it was, he feared, an element of danger in certain commercial transactions, so that it was very necessary, as the writer said, to confirm at once all important telephonic communications. The difficulty was to discriminate promptly between what were important and unimportant communications, because what at the moment might appear unimportant, possibly afterwards in the light of further developments in certain business, may turn out to be very important, consequently the safer way was to confirm every telephone message referring to work in hand. In regard to dictating letters Mr. Scott considered this acquirement easily attained. He (Mr. James) did not quite agree with that; besides he must say there was a tendency in commercial correspondence to be very slipshod in composition, and the English language was often so knocked about and abused in the most dreadful manner that it almost made one's blood run cold. They should endeavour to write their letters in somewhat good English. He did not care for the American abbreviations and the introduction of slang one sometimes met with in business communications. They should try to cultivate a certain amount of literary style within proper bounds, avoiding unnecessarily long wordy epistles. As regards buying, the writer said, "after due consideration make a point of advising the tenderers of their success or otherwise." In that again there came in an old question of business courtesy, which in these days of hurry-scurry was not infrequently neglected, for it was not unusual after inquiries were made and answered to hear no more of them. He (Mr. James) thought it was only courteous to advise tenderers whether or not their tenders had been accepted. Then as to cost keeping, in all

well-regulated establishments costs were kept in the way Mr Scott suggested, and it ought to be possible with a properly arranged system of cost keeping, at least once a month, to see what a particular ship or engine has cost up to that time. There was no use awakening up at the eleventh hour to find that considerably more than the estimated amount had been spent on wages. With regard to establishment charges he knew there was a great divergence of opinion. He noticed that Mr. Scott thought salaries of managers and non-producers should not be included in the establishment charges ; in some shipyards he (Mr. James) knew of, draughtsmen's time was kept and charged direct to the ships, but part of the drawing office work, such as estimates and designs, could not be charged direct. With regard to rent, rates, and taxes, in the case of repairing shops, Mr. Scott thought they should pass on dock dues to the credit of rent and taxes account. He was sorry to say that they did not always get dock dues nowadays, or, at any rate as much as they might, unfortunately for dock owners. It was a question as to what was the right way to deal with the dues. He thought the habit nowadays was just to let the dues go into the general cost of the job. With regard to the accumulations of goods or material ordered for particular ships, and allowed, through alterations, etc., to drift into stock ; there was no doubt this was a very important matter. Certain shipyards he had been in, one in particular, had a very rigid and exact system of stocktaking, it was not taken in winter time, when things were covered up with snow and mud, but in midsummer, during the Newcastle race week holidays. The shipyard was closed on the Friday night before the race week, and a very complete account taken of the stock. Every member of the staff had to take some department—the chief draughtsman was responsible for plates and angles, and so on. It occupied three days, and it was astonishing the things that were brought to light in that annual turn over, they were duly noted and worked up at the first opportunity. Again, under the heading of "Book-keeping" regarding the iron stock, he thought what Mr. Scott pointed out was quite correct, at any rate he had found it so in his experience. Those stocks never did agree, there was always a difference between the book stock and the actual stock, and that was chiefly because they took calculated weights instead of actual weights. In regard to the ironmongery department, he had known this kept by the foreman joiner himself, and charged just the same as in a retail shop, the daily issues were sent up to the office with the articles and prices marked in letters according to a code word. Further on in the paper, regarding wages returns and the necessity of having the wages of non-

producers kept separately, that seemed a very important item. He supposed most of them had found a number of deadheads getting into departments, so to speak, unobserved. Someone slipping in somehow or other, with no justification shown for his being there, and a sharp eye should be kept on these non-producers. Finally, with regard to the use of diagrams, he dared say that older men would regard this as a new fangled idea ; but, personally he quite appreciated the value of diagrams as pointed out by Mr. Scott. He had seen in some shipyards the costs of ironwork, carpenters, painters, joiners, etc., plotted off in curves. the ironwork according to the weight of material, and the carpentry and joinery, etc., on the cubic number or gross tonnage, according to the particular way of estimating, and it was a very useful and convenient method of recording them. There were many interesting points in the paper, and he congratulated Mr. Scott on having put so many important matters before them in so able a manner.

Mr. H. C. M'BEATH said that he was practically a stranger amongst the members, that being the first meeting he had ever attended. He felt interested in the paper seeing that they had something to do with that of which it treated at the works where he was engaged. Taking it all through he considered it a very good paper, though to his mind it applied more to shipyards than to engine works. Shipyards were worked entirely different from engine works in regard to their book-keeping, costs, and their wages ; in fact it was a different system altogether. Engine works were worked in departments, each one of them being like a shipyard in itself, therefore when making up the costs in their engine works they had to allocate prices for products from the iron foundry, the brass foundry, forge, and so on, and in the end they got the cost, which might not be the actual cost, but it was as near as they could get it by careful practice. That was a better system than if it were all in one, because if any particular department was not paying its way they could check that department by taking stock at any time. The costs say, for a set of engines, were kept posted up day by day, so that within twenty-four hours of the ship going to sea they had the entire charges. As to what was said about the correspondence it was almost like their own, and remits from the commercial department were gone through and dealt with by the managers of the different departments, upon extracts or copies of the original orders. As regarded developments, that was a thing always before everyone's mind. It did not need much pointing out because their whole efforts were to make the thing pay, not working exactly all for glory. He thought himself that

a periodical survey by the Heads through the books would be useful, though he was afraid that this was left very much to the assistants, but a periodical survey might open their eyes to much that might be going on. He for one had always been glad to have any particular foreman or manager to go through his books so that they might see what was going on, and if possible, do away with any unnecessary expense.

Mr. A. M'GLASHAN said this paper commended itself as being on a very important subject. He believed that our nation of shopkeepers always had a practical way of looking at things and while they owed a good deal to doggedness and courage and some technical skill, they probably owed more to commercial enterprise. It might be quite true what was being said, not only in technical education but also in commercial education they were being somewhat out-distanced by their enterprising rivals both in America and Germany. It was quite true what Mr. M'Beath said, they did not work for glory. The purely technical man took a pride in his work. The designer left to himself entirely would make a splendid design, and if followed out, it would no doubt result in a fine piece of work; but the wholesome restraint of having to make the thing pay reminded them that they could not live on technicalities, and this commercial spirit must be largely developed if they were to succeed. He had therefore to thank Mr. Scott for bringing the subject before them in his paper. He believed the paper as written would fit in with a moderate sized establishment, and to a very large establishment, the same principles—care, accuracy and supervision—would apply; though some of the details might not. In the matter of correspondence they could not limit it to one man or two men, and, although an engine works might, as the previous speaker said, be such a great place as to be equal in each of its departments to a shipyard, there were shipyards big enough to require several shorthand writers and typewriters to keep up efficient and accurate correspondence. He quite sympathised, though, with the proviso laid down in the paper, to see that each department was equally effective. He did not think when a shipbuilding business was very large it should be left to the control of one individual in the commercial department. That would be expecting too much from anyone. Duties and responsibility must be divided according to the size of the works, but that did not impair the principles laid down in Mr. Scott's paper. In the cost keeping he did not like the managers, technical and commercial staffs and foremen to be called "non-producers." That was a term in the paper that needed changing. They were "producers." The buying part of business had been mentioned; he thought some firms

which had been very successful had not been over speculative, simply buying in the best markets to cover requirements, and, of course, taking advantage of any rise or fall in prices. There were a lot of technicalities in book-keeping he could not go into, but the outline given in the paper enabled one to grasp the principal matters requiring attention. He thought getting rid of surplus stock very important. Valuable ground was sometimes occupied with obsolete plant little better than scrap, and owing to the changes in construction, material brought in had to be laid aside and might lie warehoused until it was out of date. The paper was one that suggested a great deal worth following out, and laid down a system of good rules which, if they could have them carefully acted up to, would give good results.

The CHAIRMAN (Mr. R. W. Vick) said his first feeling about the paper was that he should have been exceedingly glad if he could have read it thirty years ago, as it would have saved him a great deal of thought and labour in the office he had the honour to be connected with. On the whole, it commended itself to him as a perfect picture of the management of the commercial department of a shipyard. They, in many respects, followed at the Middleton shipyard the lines sketched out by Mr. Scott. He might say that they even went so far as to try the phonograph, one of the speakers alluded to, but it did not prove a success. One found that the art of dictating business letters was not easily acquired, particularly when the phonograph was the receiver of the dictation; because all the "hums" and "haws," recalling of words, &c., were reproduced, which made it rather awkward for the man who had the tubes at his ears. In regard to tenderers who were not successful and did not get notified of the fact. (He noticed a smile pass over the faces of friends.) He thought they were fairly entitled to take this liberty with their friends seeing that many took the same liberty with them. They had only that day received a reply from a firm with regard to the possible order for a ship the cost of which nearly went into six figures and was quoted so long ago as September last. Now they were asked to give another tender, which they would do with the greatest pleasure; but it pointed out the treatment meted out to them and no doubt other shipbuilders. If they asked a man for a tender for a ton of bolts they did not think it necessary to advise him if unsuccessful. With regard to getting out the wages and costs. They did not get out the costs of material during the progress of the ship as their friend had suggested. They more particularly watched the wages. Paying the wages on the Saturday they were able by the preceding Friday to know exactly how

much had gone to each department of the ship up to the preceding Tuesday night, perhaps, he should say from memory, under 50 or 60 heads, in all departments. By means of this return, they could very closely watch the wages and stop any leakages made evident. Then in regard to the "dead stock," he found it very desirable to keep a look out and clear it off as frequently as possible. The writer of the paper spoke of material being put into the costs from measurement only; well they were able to enter the great bulk of their material from actual weights and yet they found that the ledger balances did not always agree with the stocks in the yard. There was one custom they had at the Middleton shipyard and that was the system of what they called "Weekly Wage Sheets" which he thought he might mention. Every man's wages, time or piece, was entered upon a sheet and that sheet was handed to the foreman who had charge of the particular department so that he might see what every man in his department was drawing for the particular week in question. That system in their case arose from a somewhat extensive defalcation, and they adopted it in order to avoid the possibility of such a thing occurring again, for under the present system the timekeeper, the foreman, and possibly a clerk would have to be in collusion. He noticed that the technical men who had spoken had a warm side for "curves." He might say, not being technical himself, he had not the same appreciation for them; but he would try to cultivate them and endeavour to get benefit from them. He saw the practical department cultivating these "curves" and looked upon them with some admiration and was quite prepared to think they might be useful. He had studied the curves of the "bank rate" and found them certainly suggestive. There was one point the writer of the paper did not allude to and that was the treatment of invoices. He was careful to tell them that no letters went out to the yard but only extracts and instructions, but he did not mention invoices. Well, representing a large establishment from which sums of money amounting from £15,000 to £25,000 in the month were dealt with in the invoice department it would be interesting to know how he treated them. They were just as conservative over invoices as they were over letters, for they never passed outside to the yard, or even into the hands of foremen, but were kept in the office, checked off by means of day books, and very carefully preserved for certain reasons which, perhaps, he need not dilate upon.

The discussion was adjourned.

The CHAIRMAN thanked the members who had attended from a distance, and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SEVENTEENTH SESSION, 1900-1901.

PROCEEDINGS.

SIXTH GENERAL MEETING OF THE SESSION, HELD IN THE MARINE SCHOOL, SOUTH SHIELDS, ON FRIDAY EVENING, MARCH 29TH, 1901.

HENRY WITHY, ESQ., J.P., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, held in West Hartlepool, on March 2nd, which were approved by the members present, and signed by the President.

The ballot for new members having been taken, the President appointed Mr. J. H. Heck and Mr. Chas. Dowson to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Bateman, John, Engineer, Vane Terrace, Darlington.

Friederichs, Herbert F., Electrical Engineer, 1, Stanhope Avenue, West Hartlepool.

Link, Rolls Percival, Consulting Engineer, 81, Southwark Street, London, S.E.

Thorman, Thos., Marine Engineer, 40, Kings Road, Leytonstone, Essex.

GRADUATE TO MEMBER.

Robson, Robert, Electrical Engineer, 166, Rye Hill, Newcastle-upon-Tyne.

GRADUATE.

Richardson, Norman Shephard, Apprentice Engineer, 15, Wentworth Terrace, Newcastle-upon-Tyne.

INVITATIONS FROM MIDDLESBROUGH.

The PRESIDENT announced that the Council of the Institution had received and accepted an invitation from Messrs. Dorman, Long, & Co., for the members to visit their Britannia Works at Middlesbrough, and also from Messrs. Bell Brothers to visit their Clarence Works at Middlesbrough. The date arranged being Thursday, 23rd May. At the same time the works of Messrs. Richardsons, Westgarth & Co., would be open for inspection. Full particulars of the arrangements would be sent later on. It would be an interesting occasion, and he hoped as many members as possible would avail themselves of the opportunity.

Mr. F. W. JENNING'S reply to the discussion on his paper on "The Ventilating and Heating of Ships" was taken as read.

The discussion on Mr. G. M. Brown's paper on "The Efficiency of Marine Boilers" was resumed and closed.

Mr. E. GRIFFITH read a paper on "Water-tube Boilers."

MR. F. W. JENNINGS' REPLY TO THE DISCUSSION OF HIS PAPER ON "THE VENTILATING AND HEATING OF SHIPS."

The discussion being closed, the following reply by Mr. F. W. Jennings was taken as read :—

LONDON,

DEAR MR. DUCKITT, *March 27th*, 1901.

I regret I shall not be able to attend the meeting of the Institution on the 29th inst. to reply personally to the discussion on my paper, so must ask you to place before the members the following communication :—

I thank Mr. De Rusett for his complimentary remarks upon my paper. I can assure him that my observations regarding the right people to devote attention to the subject of ventilation were not in any way intended as a slur upon the naval architect, and I think he will agree with me that mechanical ventilation is a more suitable subject for the mechanical engineer to deal with than the naval architect. If ventilating engineers are given a ship to ventilate, they are able to apply a great deal of experience gained in the ventilation of buildings, which is not available to the naval architect.

Mr. De Rusett speaks of the combined plenum and vacuum system, and whilst he makes his meaning perfectly clear, I think this is somewhat of a misnomer. In my opinion any system in which a slight pressure is maintained in the ventilated portions of the building or ship should be described as a plenum system, and any in which a slight vacuum or suction is maintained should be called a vacuum or extract system. It is manifestly impossible for any system to be both at the same time, and the fact of putting in comparatively small exhausting fans to assist in getting rid of the vitiated air, such as those mentioned in the paper, does not convert the plenum into a vacuum system.

Mr. De Rusett considers the allowance of 35 cubic feet of air per minute per passenger too much. This is only sufficient to keep the degree of vitiation of the air down to about seven parts of carbonic acid per 10,000 parts of air. Assuming that normal external air contains four parts per 10,000, which is about the average, any greater amount of vitiation than this must be considered unhealthy. I do not think that any system of artificial ventilation which depends upon the assistance of stairways, skylights, etc., can be considered satisfactory. The description of the system of ventilation designed by Mr. De Rusett for

the "Oceana" and "Arcadia" is very interesting, and was probably much in advance of anything previously attempted; but it appears to be somewhat primitive compared with the exact scientific systems now in vogue. The system adopted in the "Ivernia" appears to be very similar to that described so fully by Mr. W. Maxwell Stewart, consequently my reply to the latter will also cover this portion of Mr. De Rusett's contribution to the discussion.

Mr. W. Maxwell Stewart's description of the ventilating thermotank is very interesting. I should say, however, that it is more useful for heating than ventilation, judging from the results of the tests of the system as fitted on board the "Kostroma," and given on Plate XI. In these tests the amount of air given as supplied per person is 7 cubic feet per minute, and if this is all the fresh air that is admitted to the compartment, it is quite inadequate for efficient ventilation, as the degree of vitiation would eventually reach nearly 20 parts of carbonic acid per 10,000 parts of air, which is almost as foul as the air in a badly ventilated crowded theatre.

Mr. Maxwell Stewart states that it is not advisable to allow the air to pass through the pipes at a speed of more than 2,000 feet per minute, and that, consequently, the area of the main pipe must be 8½ square feet. I may say that the speed of air through the main pipes is often as high as 12 metres per second, or 2,400 feet per minute; this would reduce the area to 7 square feet. I would also point out that, in my scheme of distribution, the main pipe from the fan is immediately divided into several branches, the largest of which would only have an area of about 2·5 square feet. It is, therefore, scarcely correct to say that a trunk having a cross-sectional area of 8½ square feet would have to come down into the passenger accommodation. It is also stated that an air pressure of 1·8 inches would not be sufficient for the delivery of the air from the openings at the fan end of the trunks. I find that the farthest distance of any outlet from the fan is about 60 metres (196 feet), and if the pipes are properly proportioned, and the connections made correctly, so as to offer as little resistance to the flow of air as possible, there is very little doubt that 1·8 inches is ample. In several buildings, ventilated on the system described during the last few years, the air has been blown over distances considerably greater than this, with an initial pressure of only 3·5 centimetres (1·38 inches). I may add that the resistance offered by the type of apparatus illustrated on Plates X., XII. and XIII. would be very much greater than that offered by the type of apparatus described in the paper. I

would also point out that the arrangement of piping indicated on Plate X. is exceedingly primitive, and would undoubtedly cause serious eddies to take place in the air in its passage through it. No difficulty whatever would be found with the temperatures, owing to the upper deck rooms requiring more heat than the lower deck, as the heat loss from each room is calculated separately, and the air supply proportioned accordingly. It is claimed as an advantage for the thermotank that each unit deals with only 5,000 cubic feet of air per minute, and that, consequently, the trunks can be made much smaller. If it be considered advisable to sub-divide the heating and ventilating plant to this extent, the type of apparatus described in the paper is easily capable of this amount of sub-division, as it is made in many different sizes ; but I would point out that if each set of apparatus is to deal with only 5,000 cubic feet of air per minute, it means that fourteen sets would be required to do the work of the four mentioned in the paper. It is also claimed as an advantage for the thermotank that it can be used for exhausting purposes, this is done by arranging the piping in such a manner that both the inlet and outlet can be connected to either the main trunk or the atmosphere. This can be done with any centrifugal encased fan without much difficulty, but the writer does not recommend it being done, as it is practically impossible to get satisfactory distribution with any exhaust system, owing to there always being a tendency for the air to short circuit from the inlet to the outlet.

It has not, hitherto, been found necessary to make provision for cooling the air with the system described in the paper, owing, probably, to the large volume of air supplied ; but, if it is considered necessary, the provision of this presents no insuperable difficulties.

Mr. Maxwell Stewart claims that the system he describes would only require one half the trunking necessary in the scheme put forward by me. I presume he means that the exhausting fans would not be necessary. I recommended the use of these in the case of large passenger ships to assist in getting rid of the vitiated air. As either type of apparatus can be fitted without these exhausting fans, I cannot see how it can be claimed that the thermotank only requires half the trunking of the other. Mr. Maxwell Stewart questions if there would be any gain in economy in using a steam engine to drive the fan. I would point out that when the heater is working, the exhaust steam from the engine is passed through it and that therefore a corresponding amount of live steam is being saved. This means that the engine is practically being driven for nothing and I cannot see how there can be any greater

economy than this. There is, however, not the slightest objection to electric motors being used if preferred. The steam consumption of the thermotank is not given, consequently it is impossible to compare the efficiencies of the two types of apparatus.

I can assure Mr. W. H. Atherton that I do not underrate the value of the services rendered to the cause of ventilation by such men as Drs. Arnott, Reid and Billings, whose works should undoubtedly form part of the library of every ventilating engineer.

Mr. Atherton mentions the new Technical School at Manchester as being heated and ventilated on the double duct system. To give some idea of the size of apparatus required for a large building of this description, I may say that there are two Sturtevant fans, each having wheels 12 feet in diameter. The heaters are arranged for use with either live or exhaust steam, separate receivers with pumps are provided for steam and exhaust drains, a third receiver with pump being provided for testing purposes for connection to either steam or exhaust drains.

Mr. Atherton speaks of the amount of steam used for the heating apparatus described in the paper. I would point out that the amount given would only be required when it was necessary to maintain an internal temperature of + 15° C. (60° F.) with an external temperature of — 10° C. (14° F.) these are of course exceedingly severe conditions. I am afraid I am scarcely at liberty to give full details of the calculations, but may say that the air supply is dependent primarily upon the heat loss, the amount of heat lost from each compartment being calculated separately and the air supply proportioned accordingly. The metric system is used throughout by my firm (The Sturtevant Engineering Co.) in their calculations.

In reply to Mr. James Andrews I would say that my statement *re* the heating and ventilating arrangements on board several Dutch cruisers having proved satisfactory, was based on the fact that in all cases the heating and ventilating plants accomplished all that was specified by the Dutch Admiralty, and that since the first ship was heated and ventilated on this system, about 10 years ago, many others had been treated in a similiar manner. I would also mention that in one ship at least, another system, after a fair trial, had been taken out and replaced by that described. In some of the cruisers the amount of air to be delivered in the various compartments was specified, in others, the temperatures to be maintained. In all cases the apparatus did all that was required. It is, of course, practically impossible to maintain a constant temperature in all parts of the ship if the exact amount of air to be delivered is specified, but it is

an easy matter to maintain any desired temperature if a free hand is given with the amount of air to be delivered. I would therefore suggest that naval architects specify the temperature they require maintained in the various parts of the ship, at the same time taking the *minimum* amount of air required for ventilation in any compartment. Mr. Andrews states that his cabin was too hot. If that were so it was entirely his own fault, as all outlets were fitted with regulating valves by which the hot air could be admitted in any desired quantity.

Re the size of air piping, the naval architect has only to say what is the maximum size of piping he can allow, and the number of sets of apparatus can be arranged to keep it down to the requisite size. In some of the Dutch cruisers it was specified that no pipes should exceed 10 centimetres (4 inches) in depth.

Mr. Andrews speaks of the loss of temperature through a distance of thin metal pipes. This, of course, depends to a great extent on the protection afforded to the pipes. If they are cleaded or covered with some non-conducting material, the loss would be very little. The loss from a length of 60 metres, as arranged in the paper, would be about 10° C. assuming that the pipes passed through the warm corridors, but were not protected. This would, however, be allowed for in the proportioning of the pipes, also the loss due to friction. I would emphasise the fact that this proportioning of the pipes is a most vital point and may easily mean the difference between an efficient plant and a non-efficient one.

In conclusion, I must express my gratification at the excellent discussion which has taken place on this paper. I think that the quality of this discussion points to the fact that the important subject of ventilation and heating has been carefully studied by many members of the Institution.

Yours faithfully,

F. W. JENNINGS.

The PRESIDENT had great pleasure in proposing that the thanks of the Institution be given to Mr. F. W. Jennings for his paper on "The Ventilating and Heating of Ships." They all looked upon it as a very interesting communication, and he thought the discussion was also valuable.

The vote was accorded by acclamation.

RESUMED DISCUSSION ON MR. G. M. BROWN'S PAPER ON "THE EFFICIENCY OF MARINE BOILERS."

Mr. J. H. HECK resumed the discussion on Mr. Brown's paper on "Some Attempts to Increase the Efficiency of Marine Boilers." He said he wanted at once to express the pleasure he had felt in reading it. Mr. Brown made many references to the good work done by Mr. Wye Williams in regard to the scientific combustion of north country coals. It would be of very great interest if any of the young members, who had not done so, would read Mr. Williams' book. There was a fortune to be made in carrying out some of the suggestions made in the book. With regard to evaporative trials he (Mr. Heck) did not consider them of much value if the water level was only kept high enough, especially was this the case in water-tube boilers; the efficiency could be made to appear very high—a bad boiler could be made to show apparently much better results than a really good boiler. In his (Mr. Heck's) opinion the plan pursued at Portsmouth Dockyard some years ago was of much greater value. The dockyard authorities gave an engine and boiler, and required you to pump out one of their dry docks. In this way it was possible to arrive at the efficiency of any machine which was tested, and also to say what the calorific value of the fuel really was. Mr. Brown had told them in his paper that the best results were got by a rapid rate of combustion and small grate area, and this opinion, Mr. Heck thought, was sound. A large grate area meant loss of coal and efficiency. Under the conditions existing at sea, for a short time, for a few hours an expert stoker would no doubt be able to manage a large grate area, but in bad weather and on long voyages when men got tired he would not be able to do so, and one of the reasons why water-tube boilers were so uneconomical was largely due to excessive grate area. He (Mr. Heck) considered that Mr. Brown in his statement, that it was certain no gain in efficiency was to be got by increased pressures, was quite unsound. Whenever an increase of pressure had been contemplated the same remark had been made and yet every one knew that every decided increase of pressure had resulted in a decrease of coal consumption. Mr. Heck considered that if, in the future, pressures of 300 to 400 pounds coupled with quintuple expansion were employed, the consumption of coal for doing a certain amount of work would be largely decreased. He (Mr. Heck) did not agree with Mr. Brown that

the efficiency of the present marine boilers was less than that of boilers made years ago. On the contrary Mr. Heck thought that the present marine cylindrical boiler was in every way a very much more efficient steam producer than boilers made formerly. He (Mr. Heck) concluded by stating that in his opinion the most efficient boiler was one that was large for the work it had to do—had a high funnel and small grate area.

The discussion was closed.

The discussion on Mr. Walter Scott's paper on "The Commercial Organisation of Shipyards" was also held to be closed, there being no further remarks offered.

WATER-TUBE BOILERS.

By EDWIN GRIFFITH, Wh. Sch.

[Read before the Institution in South Shields on March 29th, 1901.]

The writer, before reading his paper on "Water-tube Boilers," wished to say that it was written before the issue of the interim report by the Admiralty Committee of Inquiry. He was glad, however, to say that had the report been before him there would have been very little difference, but it would have enabled him to put some of his conclusions a little more strongly than they stood in the paper.

Introduction.—The object of this paper is to consider the present position of water-tube boilers from the point of view of the marine engineer, and to direct attention to some aspects of the subject that appear to require special emphasis. The term "water-tube boiler" will be understood to mean any tubulous boiler having the water inside the tubes, and the term "fire-tube boiler" any such boiler having the fire inside the tubes. The particular kind of fire-tube boiler now in general use on merchant vessels will be referred to as "the ordinary boiler." The class of water-tube boiler which is used on small high speed craft, and having small tubes whose general direction is vertical, is called the "express boiler"; and the type which has comparatively large tubes placed approximately horizontal is described as the "large-tube boiler."

Fire-tube and Water-tube boilers compared.—Given a tube, fire and water, which is the best way to evaporate the water, by putting it inside the tube or outside? This indicates the general principle involved, and the answer to the question depends on many considerations, of which the following two are perhaps the most apparent:—

a. If the water is placed inside the tube some structure is necessary for containing the fire and insulating it from surrounding objects, but, on the other hand, if the fire is inside, a separate vessel is necessary to hold the water. When the object is to form steam of considerable

pressure this vessel must be strong and correspondingly heavy, and this respect the advantage seems to be with the water-tube princip and the more so the higher the pressure.

b. When the water is evaporated any solid matter it may contain deposited, and if such deposit forms inside the tube and accumulat there, the tube will be gradually filled up and burnt. From this point of view the condition is more favourable when the water is outside the tube, because, in that case, access of a sufficient quantity of water to the heating surface cannot be so readily impeded. It therefore follows that in water-tube boilers deposits must not be allowed to accumulate in the tubes.

Before leaving this general aspect of the question, it should be noted that thermal efficiency does not depend on whether the water is inside the tube or not, but on the thoroughness of combustion and the proportion of heat wasted in each case.

Passing on to a more detailed comparison, the inherent advantages of the water-tube over the fire-tube boiler are considered to be :—

1. A reduction in weight. This is important in all vessels—naval and merchant. Generally the importance increases with the speed of the ship.

2. Steam can be raised more quickly. This is regarded of great tactical value by naval authorities, and is a convenience in yachts, tug-boats, river and channel steamers. Rapid circulation and freedom for independent expansion of the tubes are favourable features.

3. The space occupied is usually less, and the form of boiler more adaptable to the space available and more area of grate may generally be obtained in the same stokehold capacity.

4. The parts subject to pressure being of comparatively small dimensions, the boilers are suitable for higher pressures.

5. Owing to the relatively small amount of contained water, the damage caused by an explosion is less serious.

6. The parts being smaller and lighter, they are more convenient for transit and can be passed through smaller openings, which facilitates erection on board and renewals.

7. The boiler is better adapted to quick changes of temperature, an advantage favourable to endurance when such changes are frequent, as in naval vessels.

All the above benefits, however, are not found in every water-tube boiler at present, but in so far as they are absent in any particular case, such a boiler is not a good specimen of its type.

The inherent objections to water-tube boilers are:—

1. The feed supply must be quite certain and regular and receive greater attention because of the small amount of contained water.

2. The trouble from deposits, already referred to, is difficult to deal with in a thoroughly satisfactory way, and is always a source of some anxiety at sea. The necessity of keeping the boilers fairly clean, inside and out, has, however, the corresponding advantage that the efficiency of the heating surface is better maintained on that account.

3. A leaky tube cannot be plugged without putting the boiler out of service.

4. Water-tube boilers will not stand neglect and rough treatment so well as fire-tube boilers, and are, therefore, not so suitable for services specially liable to such usage.

The following characteristics are also sometimes classed as objections:—

1. The area of the water surface and the capacity of the steam space being comparatively small, there is a greater liability to prime than in ordinary boilers, which is aggravated by the use of salt water and of some qualities of shore water. On the whole, water-tube boilers (with the possible exception of the Belleville) are satisfactory in this respect, but a simple, reliable separator should always be fitted near the engine end of the steam pipe range.

2. Special care is necessary to thoroughly insulate the fire space so as to minimise the loss of heat by radiation, and to avoid all danger of setting fire to surrounding objects or unduly heat adjacent spaces. All parts of the steam space should be protected from the flames so as to preserve the material.

Economy.—There is some difficulty in comparing the economy of the two types of boilers. The thermal efficiency is usually stated in terms of water evaporated per pound of combustible (from and at 212 degs. F.) which does not give a proper basis of comparison between different designs of boilers, because almost any boiler of some promise can be made to show a high result in that sense under test conditions and with *a rate of combustion which is suitable.* It is suggested that a more valuable method for comparative purposes would be to specify a certain reasonable rate of evaporation per pound of combustible, and then observe the total evaporation per hour per ton of boiler weight. If the boilers under comparison have scantlings to suit the same requirements, the total evaporation thus obtained would represent their relative efficiencies as steam producers. On such a basis, the water-tube boiler is superior to the fire-tube, and may be said to be inherently more economical.

Comparing the economy in the usual way it may be mentioned that for H.M. Navy it is usual to specify certain rates of evaporation at certain rates of combustion per foot of grate surface on shore tests, and the requirements in this respect are so exacting that few makers of ordinary boilers would care to be bound by them.

From the point of view of economy, water-tube boilers as made are liable to have two defects, viz. :—

1. There is usually not sufficient combustion space for the expected full power of the boiler. In express boilers as installed in torpedo vessels, this space may be considered, on the whole, suitable for the power generally necessary, but large-tube boilers are intended to maintain economically a high percentage of their full output, which, however, most of those in use cannot do. Under sea conditions, to obtain an economy equal to average ordinary boilers the Babcock and Belleville boilers cannot be depended on to burn more than about 18 lbs. of coal per foot of grate per hour. (See Appendix, items 16 and 64.*) The economical capacity of such boilers ought to be calculated on this basis and not on the results of shore tests made under the most favourable conditions as to firing, etc., conditions which in some cases may be very different to what is practicable on service. The above remark refers to the Belleville boiler of the economiser type, where a second combustion chamber is provided between the generator tubes and the economiser tubes, the economy of the Belleville design without economiser being less satisfactory. The most promising boiler of this class, as regards combustion space, is the D'Allest, which has a combustion chamber provided at one side of the nest of tubes, the products of combustion being directed into this space by baffles and then passing among the tubes. In the latest practice, the boilers are worked in pairs, which have a common combustion chamber, and are fired alternately at regular intervals. (See Appendix, item 45.†) Experience with water-tube boilers tends to confirm the common impression that for the highest efficiency the combustion should be complete before the gases get among the tubes. On the other hand, in the Belleville boiler of the economiser type, the fact that the combustion is divided into two stages is of some advantage to the bottom generator tubes.

2. In the earlier designs there was not sufficient provision made for thoroughly utilizing the heat of combustion by properly passing the gases over all the heating surface, but this matter has received very careful attention of recent years, with fairly satisfactory results. There are two systems adopted, the first being to provide a tortuous circuit

* Pages 174 and 181. † Page 178.

with a comparatively small cross section, and the other to have a short circuit of large cross-section, with provision for spreading the gases all over the section. The Thornycroft boiler is an example of the first system and the Yarrow of the second. The latter method has the advantage that it requires less forcing and is probably not so severe on the tubes adjacent to the fire, the heat directed against them not being so localised. For cleaning the tubes outside (which has a vital bearing on their endurance) the fewer baffles the better, and those necessary should be convenient to remove and replace. It is also advisable that the baffling should be such as not to favour the lodgment of soot and ashes.

Some other features favourable to maintained economy are:—Feed-heating, careful and regular firing, the admission of a little air above the bars during high rates of combustion, and mechanical draught. The most economical system of feed-heating is to utilize the heat in the uptake for the purpose, but so far the endurance of the tubes in such heaters has not proved encouraging on the whole, and in the meantime some other method is preferable, the best being to use receiver steam. The economic value of feed-heating by steam depends mainly on the fact that a part of the latent heat is recovered, being transferred into the feed water instead of into the circulating water. With reference to mechanical draught, the large tube class of boiler will not stand much forcing because it is not suited for a high rate of circulation, but any boiler is a better boiler in so far as it will stand forcing. It seems likely that in course of time a satisfactory way of using some of the uptake heat will be found, and we are scarcely justified in sending heat up the funnel beyond recovery merely for the sake of producing a draught. However, the present custom of obtaining a good draught with a comparatively low funnel temperature by using a large and high funnel is economical. In some recent trials in America, there was practically no advantage gained by the use of heated air for furnace draught in Babcock boilers, but further experiments on this point seem desirable (see Appendix, items 40, 53, and 63).* In this connection attention may be directed to the Belleville practice of injecting air into the furnace under pressure to impinge on the gases and keep them from rising among the tubes before combustion takes place, which is an effort to make up for the insufficient combustion space provided.

Circulation.—The circulation should be free with adequate down-comers, preferably outside the fire space, the course traversed being as direct and unobstructed as practicable. Under such conditions the

* Pages 177, 179 and 180.

circulation will increase with the rate of combustion and so tend to maintain the efficiency of the heating surface, which improves considerably up to a high velocity of flow, the limiting speed being beyond what is reached in practice except possibly in express boilers when highly forced. A simple illustration will indicate the cause of circulation. Fig. 1 shows a test tube containing cold water and Fig. 2 the same tube heated to boiling point, a bubble of steam having just been formed at the bottom. The bubble raises the water level from *a* to *b*, producing a state of unstable equilibrium in the tube till the bubble reaches the surface, which falls slightly below *a*. The cause of circulation is therefore the tendency of the centre of gravity of the tube contents to reach the lowest point, and the energy producing circulation in this case is the weight of the water multiplied by the distance the centre of

FIGURE 1. FIGURE 2.

gravity is raised by the formation of the bubble at the bottom. If the tube is inclined, the centre of gravity is raised less than in the vertical position, and it follows that the energy causing circulation is correspondingly less, being a maximum when the axis is vertical and a minimum when horizontal. On the other hand, in an actual boiler the products of combustion cannot be so effectively brought into contact with the tube surface when the tubes are vertical, and therefore some inclination is desirable, but the best compromise as regards evaporative efficiency (in the sense suggested before) is found in boilers having the tubes nearer the vertical than the horizontal position. Boilers in the latter condition have usually the tubes discharging into headers or uptakes which are vertical or nearly so, and the general application of the above principle to such designs is shown in Fig. 3. Assuming the tube to be of the same cross-section as before, the formation of the bubble will raise the water level to the same extent as in Fig. 1, and the energy for circula-

tion produced by the formation of the bubble will be the same in both cases if the vertical leg of water is the same height. But in Fig. 3 there is much more water to circulate, the resistance of the bend has to be overcome and the bubble has a greater distance to travel, so that the circulation will be much slower than in Fig. 1. For a complete theory of circulation it would be necessary also to take proper account of the causes *retarding* circulation, but conclusions based on the above principle are supported by the facts of experience, and in cases where the circulation can be fairly described as "free," it may be regarded as the dominating factor. The influences retarding circulation are greater in boilers of the large-tube than in those of the express type, so that the latter compare even more favourably in this respect than if only the *cause* of circulation is considered. The rate of circulation governs the size of tubes, a slow flow rendering large tubes necessary so as to bring

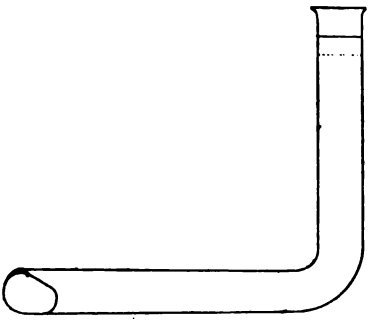

FIGURE 3

a sufficient body of water into reach of the heating surface in a given time and so prevent over-heating. Large tubes mean thick tubes and therefore a heavy boiler as the total amount of heating surface cannot be less because of the increased thickness, but ought rather to be more. There is also very little doubt that the rate of circulation in large-tube boilers might be considerably higher with advantage to the efficiency of the heating surface. The broad conclusion is that express boilers are superior in principle to large-tube boilers regarded merely as steam generators without reference to other considerations, such as endurance.

Tubes.—Copper, welded iron and welded steel tubes have been tried, but at present the approved material in navy boilers is open-hearth steel, the tubes being solid-drawn, finished cold, with smooth surfaces inside and outside. They are annealed, pickled, then thoroughly cleaned and dried, and galvanized externally by electro-deposition, the tubes being

thoroughly examined for surface defects when the latter process has been partially done, as a slight degree of zincing by this method exposes any minute cracks there may be in the surface. Although decided progress has been made in recent years in the manufacture of steel tubes, they cannot yet be quite relied upon as regards soundness and uniformity of structure. They are liable to have inherent longitudinal splits and the different tubes of the same group and even different parts of the same tube are not of the same quality. This latter feature is an important factor in promoting corrosion, and has therefore a vital bearing on the endurance of the tubes, which at present is rather a weak point in water-tube boilers. It would seem a sound practice for makers of such boilers to make their own tubes, the complete success of the boilers being so largely dependent on their proper quality. Mr. Yarrow has published the results of some trials made with nickel-steel tubes (see Appendix, item 48*) showing a much superior endurance over solid-drawn steel tubes under the conditions of the trials, and he concluded that it might pay to adopt nickel-steel tubes for boilers. On the other hand, in some endurance tests made by Mr. Worthington of the U.S. Navy (see Appendix, item 61†), although the general wastage of nickel-steel tubes was much less than that of iron or steel tubes, yet local pitting rendered them useless in about the same period. This result, however, may have been due to avoidable irregularity of structure. The greater expansion by heat of nickel-steel tubes might cause trouble in some boilers, such as the D'Allest, which is not specially well adapted for raising steam very quickly, even with steel tubes.

The controversy whether all the tube surface should be "drowned" or not in express boilers has been settled in favour of drowned tubes, which are found to have greater endurance and to be equally satisfactory in other respects. There is also a danger of burning the empty tubes when raising steam. In the Belleville boiler we still have un-drowned tubes, but they can be completely filled with water when the boiler is not in use, or when raising steam quickly, which was not the case in the express boiler. There is still a difference of opinion as to whether the tubes of express boilers are better bent or straight, the tendency now being to favour slightly bent tubes (such as those of the Blechynden boiler) this being the attitude of the British Admiralty, whose views naturally carry much weight. The advantages claimed for straight tubes are that they are easier to make, to examine, to clean, and that fewer spares are necessary, also that the supposed need to curve the tubes to provide for their expansion is shown

* Page 179. † Page 180.

by experience not to be necessary. On the other hand, it is said that as a matter of fact the tubes in Yarrow boilers *do* become bent in service and that having curved tubes reduces the risk of leakage at the ends and of damage in case of shortness of water or of overheating the tubes, the burning of copper tubes in such boilers being instanced as showing the liability to overheating. Apart from the question of replacing a tube, which might of itself in some cases decide the matter in favour of curved tubes, the advocates of straight tubes urge further that with baffling pieces fitted between the tubes of a Yarrow boiler, there is no serious distortion on service, and that though the tubes may become somewhat bent in time, this does not appear to be a sufficient reason for starting with them in that condition. It is pointed out that the tubes of large-tube boilers also become bent in use sometimes, but it is never advocated on that account that they should be put into the boiler bent when new. Some makers compromise the matter by making the two rows next the fire with a slight curvature towards the furnace, leaving all the other rows straight. In most designs of water-tube boilers the tubes nearest the fire are liable to be overheated, and as a large percentage of the total evaporation takes place in them they should be larger than those more remote so as to admit sufficient water. Their pitch should also be wide, so as to allow the gases of combustion to pass freely to the centre tubes. In the D'Allest boiler, the lower tubes are made on the Serve principle so as to absorb more heat, but the difficulty of cleaning is increased. In boilers having vertical or approximately vertical tubes, it might prove an advantage to fit some form of retarders in the hottest tubes, where the circulation is very rapid. If made of a suitable material, such retarders might possibly help to preserve the tubes from internal corrosion.

There is a general agreement that the tubes of large-tube boilers should be straight with as much freedom for independent expansion as practicable.

Endurance.—The most valuable experience on this point has been with express boilers, which have been in use a sufficient time for comparison with the loco-marine type, which they displaced, the results being not unfavourable to the water-tube boiler. The tubes in this class have lasted on the average from three to five years, which is fairly good when their thickness is considered, and the tubes now available will probably last rather longer. (See Appendix, items 26 and and 42.*)

In large-tube boilers the results have been rather unequal and not

* Pages 175 and 177.

so satisfactory, though on the whole, not discouraging. (See Appendix, items 45 and 52.*) The chief cause of trouble has been the formation of deposits in the tubes, the circulation not being sufficient to keep the tubes clean under all conditions of service, and this danger will always be present in the case of water-tube boilers having tubes only slightly inclined from the horizontal, unless the water admitted is practically free of injurious ingredients. In this connection it should be noted that the tubes of ordinary boilers in naval vessels are generally renewed every four or five years on the average, which is the most fair basis of comparison with water-tube boilers fitted in similar vessels and subject to the same conditions of service. Improvement in the quality and uniformity of tubes may be expected to continue, and to have a favourable influence on their endurance.

The causes of internal corrosion and injury in boilers are considered to be :—

1. The admission of oil with the feed water. Mineral oil only should be used for internal lubrication of main-engines and auxiliaries, and the quantity reduced to a minimum ; also efficient filtering is necessary.

2. Solid matter deposited from the feed water. The loss of fresh water should be avoided, and the make-up feed produced by an evaporating plant. All possible provision should be made to prevent any deposits accumulating in the tubes, even if admitted into the boiler. Sea-water contains magnesium chloride, which, when liberated, attacks iron, and should be neutralised by admitting a solution of lime into the feed. Sea-water being always liable to enter the boiler by leakage in the condenser or by priming in the evaporator, a small quantity of lime should always be added to the feed in large tube boilers, the amount being largely increased when salt feed is in temporary use. In the British Navy double condensers are now fitted in each engine room with independent connections, so as to be able to deal with leakage.

3. Air in the feed water. The admission of the feed should be such that no air comes in contact with any heating surface. It is usually thought that zinc slabs suitably placed will absorb the oxygen in the air and thus protect the boiler, but in some cases the presence of zinc has failed to arrest this local corrosion. (See Appendix, item 52.†) Great care is necessary in the arrangement of hot-well and feed system generally, to ensure that no air will be carried into the boilers by the feed water except that actually in solution, which can be reduced by feed-heating.

* Pages 178 and 179. † Page 179.

4. Carbonic acid in the feed water. This should be neutralized by the use of caustic soda, and operates chiefly when shore water is used.

5. Galvanic action. This cause of corrosion is due to a want of uniformity in the boiler material. All internal fittings should be of steel galvanised, and zinc slabs, suitably disposed, should be fitted and periodically renewed. Mill scale should be removed from all the boiler material. Fresh water is a very bad conductor of electricity, and its use minimizes the effects of galvanic action.

It has been suggested that water is decomposed (into H and O) to some extent in high pressure boilers, but there does not appear to be

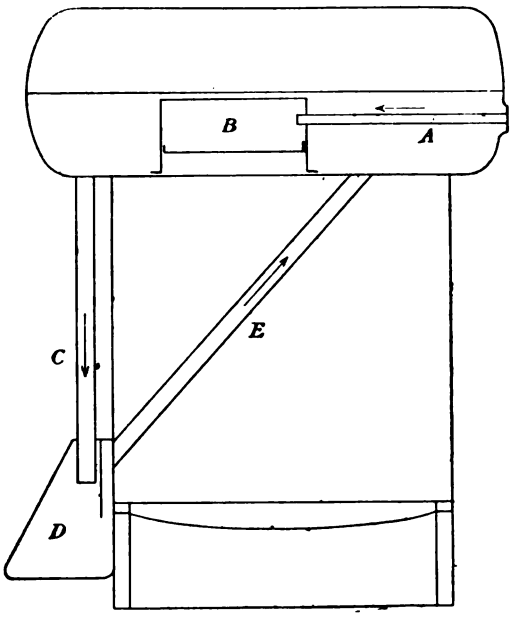

FIGURE 4.

sufficient evidence of this action under normal conditions, and the observed effects can usually be otherwise explained. If this theory was sound, corrosion would probably be more general and rapid in boilers than it actually is found to be.

It will be noted that corrosion is very largely caused by the introduction of injurious elements with the feed water, and Fig. 4 shews in a diagramatic way the features found in various boilers for dealing with the matter, although there is no actual boiler which conforms to the diagram in every respect. The feed water, already heated, enters through the

pipe A into the pan B, in which part of any solid matter present is deposited, and air mixed with the feed is liberated directly into the steam space. Passing over the edge of the pan, the feed water joins the general circulation down the pipe C, which is outside the fire space, the lower end opening into an enlarged space or vessel, which collects most of the deposits remaining in the water before it passes up the heating tube E. The vessel D is fitted with a blow-off at the bottom, and the inlet from C should be arranged so that the velocity of flow is suddenly reduced on entering. With a good circulation, the deposit formed during evaporation in the tube E will be swept up into the top drum and carried down again through C into the vessel D. The most favourable conditions of tube E are that it should be straight, of uniform bore, and approximately vertical. Any air in solution when the water enters the tube will be liberated inside the tube, and this cannot possibly be avoided, a thin coating of lime in the tube being perhaps the best protection against its effects.

It is seen that from the point of view of deposits, the large-tube boilers are not good in principle, and are therefore not well adapted for the use of water which may form such deposits, but the action of several designs of this class is quite satisfactory when using water that suits them. Although ample evaporating plant is necessary with any type of water-tube boiler, it is obviously most desirable, and almost a necessity, in view of possible contingencies, that every boiler fitted on a ship should be capable of using salt water for making up feed without disastrous results. When this has to be done with large-tube boilers, they should be hard-fired, plenty of lime admitted, and each boiler should be put out of use for cleaning after a few hours' working. Having an auxiliary boiler of ordinary type which can be used as a reserve method of making up feed for the main boilers is one plan of dealing with the difficulty. Such express boilers as have their tubes straight or approximately so, have given promising results when using salt water, especially when the very small quantity of contained water (a highly unfavourable feature) is taken into account. (See Appendix, item 37.*) Experience suggests that a boiler designed as indicated in Fig. 4 and containing as much water in proportion to evaporative power as, say, the Babcock boiler, would act fairly well when using salt feed if managed with reasonable care. The great merit of the large-tube boilers which accounts for their use is that the tubes can be readily examined, cleaned, plugged, or renewed, and this advantage is vital, though it will become less so if tubes become more reliable. It will always be necessary, however, to be able to

* Page 176.

conveniently keep the tubes clean in any water-tube boiler. As we have seen, the disposition of the tubes in large-tube boilers favours the formation of deposits inside them, and thus causes much of the necessity for cleaning, the convenience for doing which is one of their main advantages. The tubes in such boilers are not so easily cleaned as they are sometimes supposed to be, because they gradually get bent, and the removal of any hard scale formed inside becomes then very difficult and finally necessitates the removal of the tubes. It is easy to make too much of the facility for renewing a tube, but a tube can be replaced in some of the express boilers as quickly as in large-tube boilers, except in the Niclausse, which is unrivalled in this respect. Plugging a leaky or doubtful tube is usually more convenient than renewal at the time, and the most valuable comparison to make on this point between different boilers is to consider how long it takes to plug a tube-hole effectively from full steam to full steam. Every water-tube boiler must be put out of service for plugging a tube, so that the time taken to get at the tube ends may be only a small part of the total time lost. Bearing on the possible suitability of boilers of a modified express type for large vessels, our own Admiralty consider "that the experience gained with these boilers up to the present in destroyers, torpedo gunboats, and third-class cruisers, does not justify their use in larger ships, though they have been adopted for this purpose in France and some other foreign navies," the objection to them being on the grounds of poor endurance and economy. (See Appendix, item 62.*) It is not suggested, however, that boilers of this class for larger vessels should be of the same scantlings and proportions as fitted in small high speed vessels, as there would be an ample margin of weight which could be exploited in the interests of endurance and a larger quantity of contained water, yet having a good saving in weight compared with large-tube boilers even when the rate of combustion was kept within an economical limit. It seems probable that a form of boiler will be evolved more suitable for large vessels than either the express or large-tube boilers as at present made, and that such a boiler will, in its main principles, be more like the express than the large-tube type.

It is obvious that a system of properly treating the feed water *before* admission into the boiler would be an immense advantage if it could be carried out in a simple and reliable way. Although precipitation has been successfully tried on land (see Appendix, items 3 and 4†) when using qualities of fresh water unsuited for boilers, similar treatment has not done so well with sea water so far, but the gain that would result fully justifies further efforts in this direction. It would then not be necessary

* Page 180. † Page 172.

to supply evaporating plant for the boilers, moderate leakage of sea water into the feed system would not be a serious matter, and there would be no deposits to interfere with the action of feed pump, feed regulators, check valves, and other boiler mountings.

Construction.—Experience gained with ordinary boilers in constructional features should also apply to water-tube boilers, so that engine details may be considered as not specially suitable for any boiler work. Such fittings as screwed nipples in fire spaces, for example, will probably not be among the survivals (see Appendix, item 42*). In addition to being more suitable for service conditions, methods of construction which have been common in boiler works in the past are also an advantage to makers, suiting existing plant and traditions and avoiding trade disputes. The Normand, Thornycroft, Yarrow, Blechynden, Babcock, and D'Allest are all good boilers in this respect.

Cost.—The cost of express boilers is less than that of the loco-marine boilers in similar vessels, but large-tube boilers generally are more costly than ordinary boilers, although in some designs there is very little difference. On the whole, it cannot be said that water-tube boilers are inherently more costly than ordinary boilers.

Management.—Greater care is necessary with the firing and the feeding than in ordinary boilers. For express vessels in navies, the necessity for the highest speeds on special occasions is the dominant factor, but in all other vessels the boilers should be so designed that they will do well without a great deal of extra attention compared with ordinary boilers. This necessitates a large and suitable combustion space and sufficient contained water and area of water level to keep the water without feed-regulators. Boilers should be designed and made to suit the amount and quality of attention they are likely to get on the intended service, which will depend more on the past habits of the men in the stokehold than on the ideas of the boiler designer.

Conclusion.—The tactical value of increased mobility will compel naval engineers to persevere with water-tube boilers (see Appendix, items 38 and 45†), and the experience gained by them combined with the improvements brought about by their requirements will be of great value to engineers connected with merchant vessels, and the extended use of this type of boiler for such vessels may be expected. Their advantages are specially suited for yachts, channel and river steamers; and it is interesting to note that the Haystack boiler which has been very successful for many years on the Clyde river steamers, is a form of water-tube boiler with vertical tubes. The express boiler is also being tried for

* Page 177. † Pages 176 and 178.

Channel service. Some other well-known examples of water-tube boilers on merchant vessels are the Belleville and D'Allest in the French marine, and the Babcock in Messrs Wilson's ships and on the Great Lakes of America. Although the Messageries Maritimes Company report favourably of the Belleville boiler (see Appendix, item 27*), this type has not been found satisfactory by Messrs. Wilson (see Appendix, item 28*) or on the Great Lakes. On the latter service, it may be mentioned that cheapness of transit is reduced to a minimum, and as a result of experience during the past few years the Babcock boiler is growing in favour. The water, however, is fresh and well suited for boiler use (see Appendix, items (17, 45 and 47†).

The subject of this paper has reached a stage that demands the attention of all engineers connected with marine work, even those who are only directly interested in merchant vessels. From such experience as is available, an effort has been made to present some of the main considerations which govern the design and use of water-tube boilers rather than to compare the respective merits of particular boilers, because it is considered that the most important matter in dealing with a new development is to be guided by sound general ideas, and it is hoped that what has been said will lead to a discussion which will prove helpful in this respect.

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* Page 175.

† Pages 174 and 178.

APPENDIX.

The information on which this paper is based has been obtained partly from personal and partly from published sources. The writer has had some aquaintance with installations of Belleville, Babcock, Thornycroft and Yarrow Boilers, and he is also indebted to engineering friends for communications on the subject. The published matter consulted consists mainly of contributions to Technical Societies since 1890, and a list of such papers, etc. with a brief indication of their contents, in so far as they concern the present purpose, is appended. A large number of the articles are of American origin, these having been included not only on account of their intrinsic value but also because probably they will be new to many members of the Institution.

1890.

1.—*Report of the Chief of the Bureau of Steam Engineering, U.S. Navy.*—The results of shore trials of Ward & Cowles Water-Tube Boilers made by a U.S. Navy Board, which led to the adoption of Ward Boilers in conjunction with ordinary boilers for the U.S.S. "Monterey," a coast defence vessel.

1891.

2.—*Journal of the Royal United Service Institution,* "Belleville Boilers in Ocean-going Vessels."—Experience with these boilers on the vessels of The Messageries Maritimes Company since 1884 described. Considered preferable to ordinary boilers for pressures above 100 lbs. per square inch, although the Belleville type is stated to be 10 per cent. more costly and 10 per cent. less economical than ordinary boilers.

3.—*Institute of Naval Architects,* "Boiler Deposits." VIVIAN B. LEWES.—Nature of Deposits and their effects considered. Grease filters advocated, and the use of precipitator tanks for the feed water suggested. Successful use of precipitator for a month's trial described.

1892.

4.—*American Society of Naval Engineers,* "Boilers and their Deterioration." IRA. N. HOLLIS, U.S. Navy.—Experience with ordinary boilers in the U.S. Navy described. Life of tubes three or four years and of boilers about 10 years. Author recommends use of filters, precipitators, fresh water, soda in feed and zinc in boilers. Short life of navy boilers considered to be largely caused by the frequent variation in their temperature, a requirement for which their rigidity is not well adapted.

5.—*Army and Navy Register, January 16th,* "Boilers in English War Vessels."—Difficulties with these boilers (ordinary type) considered to be due to their inadequate size for full power. A common combustion chamber for opposite furnaces in double ended boilers condemned.

6.—*American Society of Naval Engineers,* "Preservation of Boilers when not in use." Order issued for the French Navy, dated April 14th, 1892, requiring ordinary and Belleville boilers to be filled with fresh water with milk of lime or soda in solution when not in use. Boiler casings to be kept closed and to have quicklime placed inside.

7.—*Report of Admiralty Boiler Committee, December 9th.*—Refers mainl ordinary boilers, advising that no sea water be used to make up feed and double-ended boilers should be omitted so as to get more sub-division of powe trial of water-tube boilers recommended, the type to be selected for vessels to have straight tubes, readily cleaned and examined.

1893.

8.—*Institute of Naval Architects*, "Water-Tube Boilers for Marine Purpc J. T. MILTON.—The claims made for water-tube boilers stated, experien French vessels referred to, and the leading designs described and illustr Tone of paper neutral.

In the discussion, Mr. Yarrow favoured straight tubes, and considere water-tube boiler better than the loco-marine boiler formerly made by his Mr. Barnaby preferred the Thornycroft boiler with the bent tubes, and ir course of his remarks stated that the tubes in the loco-marine boiler lasted from to six years. Mr. Pratten directed attention to the multiplicity of parts d the large number of boilers in installations of high power, but thought water- boilers suitable for the navy and for passenger steamers, though probably nc tramps. Sir W. H. White (then Dr. White) referred to the fact that water- boilers were being tried in H.M. Navy for large vessels, and he expected results.

9.—*American Society of Naval Engineers*, "Care of Marine Boilers." Ro FORSYTH.—Corrosion in ordinary boilers, its causes and remedies. The u filters and feed-heaters and provisions for circulation inside boilers advocated.

10.—*American Society of Naval Engineers.*—Description of the Ward w tube boilers on the U.S.S. "Monterey," with complete trial results of the v The Ward and ordinary boilers were worked in battery without trouble, and action considered quite satisfactory.

11.—*The Times, November 22nd.*—Shore trial of a Yarrow boiler H.M.S. "Hornet" described. Steam raised to 100 lbs. pressure in 20 min and to 190 lbs. in two minutes more by using steam blast in funnel. No leak

1894.

12.—*Institute of Naval Architects*, "Water-Tube Boilers." J. T. MILTC Further designs of water-tube boilers described and illustrated. Experiment French Naval Engineers on D'Allest boilers show the advantage of the combu chamber for economy. Tubes should be solid-drawn, and their durability dep largely on keeping the outside free from soot and ashes, and the inside c Mud chambers should be provided for depositing the impurities in feed water.

13.—*Institute of Naval Architects*, "Comparison of Cylindrical and W Tube Boilers." JAMES HOWDEN.—The only advantage of water-tube boilers ylindrical boilers considered to be ease of transit, which accounts for their u and, notably in the U.S. The accuracy of the author's comparative figures enerally questioned in the discussion, which was common to this and Mr. Mil aper. Mr. Seaton was in favour of straight solid drawn tubes, easily repl Mr. Yarrow advocated straight tubes because they are easy to make, to exan o clean and to replace by spare; and he did not consider downcomers neces n his boiler. Mr. Thornycroft preferred curved tubes and thought downco dvisable in all cases, though perhaps not essential in some designs.

14.—*American Society of Naval Engineers*, "Marine Boilers." WA McFARLAND, U.S. Navy.—Water-tube and ordinary boilers compared,

advantages of and the objections to water-tube boilers being stated and discussed. The corrosion of tubes had been found a serious trouble with ordinary boilers in the U.S. Navy, and was not peculiar to water-tube boilers, but the tubes of the latter could not be so readily plugged. The engineer of the "Monterey" had reported that no trouble was found with the feed, one pump feeding the Ward and the ordinary boilers in battery, and without feed regulators. Water-tube boilers on land had worked for ten years without corroding tubes, when served with suitable water, and five years experience of water-tube boilers on the launches of the U.S. Navy had been quite satisfactory.

15.—*Institute of Naval Architects*, "Circulation in the Thornycroft Water-Tube Boiler." J. I. THORNYCROFT.—The Thornycroft water-tube boiler considered superior to the loco-marine boiler. Experiments described shewing the circulation to be better than in boilers having "drowned" tubes. Salt water and some qualities of fresh water cause priming. Author in favour of large combustion chambers, and opposed to zincing tubes inside. Automatic feed device necessary with his boiler.

1895.

16.—*American Society of Naval Engineers*, "Tubulous Boilers in the French Navy." J. K. ROBISON, U.S. Navy.—A description of the D'Allest, Niclausse and Belleville boilers, and a detailed account of their working on French merchant and naval vessels, under the author's observation. The merits of the different boilers considered to be in the order in which they are named above. D'Allest decidedly more economical than the others, but could not raise steam so quickly. Only about 15 lbs. of coal per square foot of grate could be economically burnt in the Belleville and Niclausse. None of these boilers suitable for using salt water, except for a short time.

17.—*American Society of Naval Engineers*, "Trials of Lake Steamers 'Zenith City' and 'Victory.'" B. C. BRYAN, U.S. Navy.—A description of the machinery of the above vessels, and a comparison of their voyage performances, as observed by engineer officers of the U.S. Navy. The engines of the two vessels were from the same patterns, but the boilers of the "Zenith City" are of the Babcock type, and those of the "Victory" are of the ordinary marine type. The results were practically alike as regards power, economy, and amount of attention necessary, but the weight of the machinery is about 70 tons less (for 1,600 i.h.p.) in the "Zenith City" than in the "Victory," and the ability to raise steam quickly is considered of great commercial value on the Great Lakes.

18.—*American Society of Naval Engineers*, "Tests of the Boilers of the Steam Yacht "Wild Duck." I. N. HOLLIS.—Tests made on a Belleville boiler, which had been in use on the above yacht for four and a half years without repair. The boilers appeared to be in a thoroughly good condition, with no corrosion apparent, the author's impression of their endurance being very favourable. The boiler worked well during the tests, being fed with salt water of six times the density of the sea (maximum) for 12 hours without bad effects, though the tubes about the water level were heavily salted.

19.—*Rivista Marittima, Rome, August and September*, "Water-Tube Boilers." NABOR SOLIANI.—Principles of design and the leading features of water-tube boilers analysed, the following being some of the matters considered:—Circulation, size of tubes, steam pressures, drowned *v.* partly drowned tubes, curved *v.* straight tubes, deposits and corrosion, steam space, tube joints and size of units. Author favourable to the water-tube type.

20.—*Institute of Marine Engineers*, "Presidential Address." A. J. DURSTON.—The question of iron r. steel tubes referred to, the former having no advantage, as regards leakage.

21.—*Institution of Civil Engineers*, "Torpedo Boat Destroyers." J. I. THORNYCROFT and SYDNEY W. BARNABY.—Results of an experiment on a Thornycroft boiler by Professor Capper given. Regularity of feed very favourable to economy.

22.—*American Engineer and Railroad Journal*, "Corrosion of Steel Boiler Tubes." W. H. GIBBONS.—Material must be spongy to enable the tubes to be welded properly. The holes in this spongy structure get filled with slag, which gradually loosens under conditions of use, and pitting is thus started.

1896.

23.—*Institute of Naval Architects*, "Water-Tube Boilers." J. WATT.—Model experiments described, showing relative evaporation in the different rows of tubes. Horizontal tubes found more efficient than vertical. Large bottom rows advocated. Author considers that the water in the lower tubes is decomposed and causes corrosion.

24.—*Institute of Naval Architects*. "Compound Marine Boilers." NABOR SOLIANI.—A compound marine boiler suggested, as suitable for merchant vessels, a nest of water tubes being placed in the space usually occupied by the combustion chamber and the fire tubes of the ordinary boiler retained

25.—*Institute of Naval Architects*, "Circulation in Water-Tube Boilers." W. H. WATKINSON.—Experiments on circulation made with glass models of leading designs, with the author's explanations of the results.

26.—*Institute of Naval Architects*, "The Discussion on the above three papers." A. J. DURSTON.—In favour of downcomers, and of bent tubes for express boilers, being safer in case of shortness of water; also straight tubes become bent in use. The tubes of express boilers last from 3 to 5 years.

A. F. YARROW.—Considered straight tubes better than curved. A large combustion space of great value. That part of the heating surface which is remote from the fire only of small importance. Insides of tubes galvanized in the boilers made by his firm.

J. A. NORMAND.—The tubes of express boilers obtain very high temperatures when working, the failure of copper tubes in such boilers proving this. He had given up reducing the bore of the tubes at the lower ends.

J. I. THORNYCROFT.—Favourable to discharging above the water level, but he recognised the merits of straight tubes.

A. BLECHYNDEN.—Copper when dulled by smoke was practically not a better conductor than iron, and therefore using copper tubes was a mistake.

27.—*Engineering, January 10th*, "Report on the Belleville and Cylindrical boilers in service on the mail steamers of the Messageries Maritimes Company," by the Engineers for the Directors of the Company.—No trouble experienced with the feeding of the Belleville boilers. Coal used for six months on two vessels fitted with Belleville boilers compared with the amount used on two others having ordinary boilers, the economy being practically the same in each case.

28.—*North-East Coast Institute of Shipbuilders and Engineers*, "Combustion and higher steam pressures." J. R. FOTHERGILL.—The experience of Messrs. Wilson, of Hull, with water-tube boilers, given in a letter from Mr. Spear. Belleville boilers not satisfactory, but the Babcock type was doing better in their vessels, though trouble had been caused by the rapid corroding of the feed-heater tubes. The uptake heaters not fitted in the later vessels. Economy about the same as with ordinary boilers.

29.—*American Society of Mechanical Engineers*, "The Effects of Retarders in Fire Tubes of Steam Boilers." J. M. WHITHAM.—Some experiments described, one conclusion of the writer being that retarders should not be fitted in the tubes of water-tube boilers.

30.—*Engineering, January 10th*, "The Yarrow Boiler." A. F. YARROW.—Method of expanding tubes by power described, also system of feeding by separate pump for each boiler.

31.—*Engineering, January 10th*, "Yarrow's Experiments on Boiler Circulation."—The circulation, once started, was increased by adding heat either to the "up" tubes or "down" tubes, being maintained by heating the down tubes only when the pressure exceeded 50 lbs. per square inch. As the tubes remote from the fire act effectively as down-takes, separate tubes for this purpose considered by Mr. Yarrow to be unnecessary in his boiler.

The experiment indicated that even with extreme forcing there was no appreciable difference in temperature between the hottest tubes and the contained water. Bending the tubes therefore regarded a mistake.

1897.

32.—*Institute of Civil Engineers*, "Use of Water-Tube Boilers in the Mercantile Marine." A. E. SEATON.—The water-tube boiler considered suitable for merchant vessels, especially for channel steamers, and likely to become a necessity owing to the demands for higher pressures. Inherently not more costly or less lasting than the ordinary boiler. A compound boiler may come into use to meet the danger from shortness of feed in water-tube boilers.

33.—*Institute of Naval Architects*, "Water-Tube Boilers in High Speed Ocean Steamers." P. SIGAUDY.—The use of water-tube boilers of express type advocated because of the great saving in weight of machinery.

34.—*American Society of Naval Engineers*, "Trial of U.S. Gunboat 'Annapolis' C. H. MATTHEWS, U.S. Navy.—Vessel fitted with two Babcock & Wilcox boilers, having feed-heaters in the up-takes. Lower tubes, 4 inches diameter others 2 inches. Results of trial quite satisfactory.

35.—*American Society of Naval Engineers*, "Trials of U.S. Gunboats 'Wheeling' and 'Marietta.'" F. C. BEIG, U.S. Navy.—"Wheeling" has two ordinary boilers with Howden's forced draught, and "Marietta," two Babcock & Wilcox boilers, and they are otherwise alike. In "Wheeling" the i.h.p. was 10·15 per ton of machinery weight and in the "Marietta" 9·34 per ton; and the coal consumptions per i.h.p. per hour were 1·72 lbs. and 2·18 lbs. respectively.

36.—*American Society of Naval Engineers*, "Trial of U.S.S. 'Nashville.'" W. STROTHER SMITH and C. B. PRICE, U.S. Navy.—Vessel fitted with four Yarrow boilers of 252 lbs. pressure and two ordinary boilers of 154 lbs. pressure. The engines are quadruple expansion, the ordinary boilers supplying steam to the first receiver. The Yarrow group supplied by one feed pump, each boiler having a feed regulator of the Thornycroft type. Everything worked well on the trial.

37.—*Engineering, 19th March*, "Salt Water Feed in Yarrow Boilers."—An account of the successful use of Yarrow boilers with salt water feed, trials lasting seven or eight hours daily for a week, the boilers being cleaned after each trial. Only a slight scale formed at high densities, and some trouble from priming was experienced at the highest revolutions.

1898.

38.—*American Society of Naval Engineers*, "Water-Tube Boilers a necessity." J. K. ROBISON, U.S. Navy.—Results of experiences in the U.S. Navy during the

war with Spain. During war, full power must be available at very short notice, and with water-tube boilers, a few can be under steam and the remainder cleaned and ready to light up, and most of the boiler room men off duty till actually required. Uniformity of type most vital so that same spare tubes and fire-bars will serve the fleet. Rate of combustion above 35 lbs. per square foot of grate will not be practicable under war conditions. The following considered good features:—Ample grate surface, simplicity, large combustion space, a fair quantity of contained water, straight tubes free to expand and not too small in diameter.

39.—*American Society of Naval Engineers*, "Water-Tube Boilers." DARWIN ALMY.—Free circulation and free expansion of tubes advocated. Tubes should not be above 2 inches diameter, but should be thick for durability. The grate area in one furnace should not greatly exceed the practice in ordinary boilers.

40.—*American Society of Naval Engineers*, "Trials of the Niclausse Safety Water-Tube Boiler." J. M. WHITHAM.—Description and results of trials of a stationary boiler at W. Cramp & Sons', Philadelphia. Burning 13·7 lbs. of coal per square foot of grate, the efficiency of the boiler is given as 77·5 per cent. Boiler put out of service, a tube removed and replaced in 76 minutes from full steam to full steam. The following points came out in the discussion on this and the preceding paper:—

Mr. W. M. M'FARLAND referred to the low economy at high rates of combustion in water-tube boilers. Improvement in this respect necessary.

Mr. JOHN PLATT considered that tubes should be thick, and was opposed to screwing the ends.

Mr. CHARLES WARD.—Comparisons with Howden's system not fair unless an equivalent air heater is used with the water-tube boiler. Fires should be thin. Referred to yacht with water-tube boilers in use for eight years without boiler repairs.

Mr. EMIL THEISS.—High temperature of escaping gases should be reduced either by better distribution of gases among heating surface or else by air heating as in Howden's system.

Mr. J. B. EDSON spoke of the importance of free circulation, a steady water level with reliable water gauge, and a proper insulation of the fire from the boiler surroundings.

41.—*Report of Manchester Steam Users' Association.* C. E. STROMEYER.—The removal of scale should be done immediately after water is run out, when scale is soft and muddy.

42.—*American Society of Naval Engineers.* "Water-Tube Boilers. J. A. SCOTT, U.S. Navy.—Tubes of express boilers last from two to eight years, average five or six years. When not in use, best practice is to completely fill boilers with fresh water having a solution of lime, and outside should be kept perfectly dry. Mr. Normand quoted in favour of drowned tubes, rapid circulation and feed heating. Gases of combustion should impinge on heating surface. Large grates need very careful firing. Inlet of air under grate and outlet of gases should be arranged to give a uniform rate of combustion all over grate surface. In express boilers air inlets necessary above fire bars for high rates. Screwed joints in the fire space most objectionable.

In boilers for merchant service, the tubes should be straight and nearly vertical, and proper provisions made to fully utilize the heating surface. Any baffles among the tubes should be easily removable for cleaning tubes. There should be a large combustion space and ample steam space. Such boilers should be suitable for forced draught on the closed stokehold system or else for induced draught. Closed ash-pit system not so applicable.

43.—*Institute of Engineers and Shipbuilders in Scotland*, "Combustion in Water-Tube Boilers." JAMES WEIR.—The furnace, bridge and combustion chamber considered necessary in water-tube boilers as in ordinary boilers to secure efficient combustion. The "Weir" boiler designed to meet this requirement. Will burn any kind of coal, and does not produce smoke, a vital advantage for naval purposes.

44.—*American Society of Naval Engineers*, "High pressure at sea." W. R. CUMMINS.—In some boilers of the express type, the gases of combustion travel too short a distance before reaching uptake. The large-tube boilers usually superior in this respect. In the latter, the space for combustion is too low and too small.

1899.

45.—*American Society of Naval Engineers*, Discussion on Mr. Robison's paper, "Water-Tube Boilers a necessity." MR. CHARLES WARD.—Management of water-tube boilers of great importance. Case quoted of a vessel's boilers being ruined in two years, whereas a sister ship, by same builders, had run between five and six years without any boiler repairs. Pennsylvania Railroad had used water-tube boilers afloat for years with good results. Salt water and oil should not be admitted to boilers. The tubes of the Thornycroft boilers of U.S.S. "Cushing" were renewed after six years' service, the insides being then in quite good condition. The tubes of the boilers of "Hudson," with Ward boilers, not in need of repairs after six years' use.

MR. THORNYCROFT was not satisfied of the need of cleaning the inside of tubes in all boilers. He was opposed to straight tubes.

MR A. F. YARROW advocated straight tubes, and directed attention to the great advantage of duplication of parts.

MR. D'ALLEST explained that it was their latest practice to fit the boilers in pairs, with a common combustion chamber for each pair, the boilers being fired alternately with very good results. A systematic method of firing adopted, regulated by electric bells, and found quite practicable on service.

MR. JOHN PLATT favoured Thornycroft boilers for large as well as small swift vessels.

MR. W. D. HOXIE thought water-tube boilers suitable for merchant vessels. Found very suitable on Great Lakes, where competition in cargo-carrying is the keenest in the world. The ships are only six hours in port, the boilers being cleaned and ready again in that time. The express boiler not suitable for merchant service, because not durable enough.

ADMIRAL MELVILLE considered that Mr. Robison put the rate of combustion too low. The boiler units should not be too small. Agreed with author that water tube boilers are a necessity in war vessels. He was in favour of straight tubes, though he recognised the merits of those express boilers which have curved tubes.

MR. J. K. ROBISON, in his reply, referred to the "Oregon" during the war, when only 30 lbs. of coal per square foot of grate could be burnt with four inches air pressure in the stokehold, and yet the men and the coal were as good as they are ever likely to have in war.

46.—*The Bureau of Steam Engineering, U.S. Navy.*—Report of recent advances in the manufacture of high-grade boiler and pipe material. Describes improvements in boiler steel in recent years, and gives the requirements for the U.S. Navy.

47. *American Society of Naval Engineers*, "Test of the Machinery of steamer 'Pennsylvania'" (Great Lakes). B. C. BRYAN and W. W. WHITE, U.S. Navy.—

This vessel fitted with two Babcock boilers, the total i.h p. being about 1,400. The object of the trials described was to test the working of mechanical stokers, which was considered satisfactory.

48.—*Institute of Naval Architects*, "Some experiments having reference to the durability of Water-Tube Boilers." A. F. YARROW.—Tubes with 25 per cent. nickel considered twice as durable under working conditions as tubes of mild steel, as now used. This advantage would probably be worth the extra cost, in Mr. Yarrow's opinion.

49.—*Institute of Naval Architects*, "The Boiler arrangements of certain recent Cruisers." F. T. MARSHALL.—Some installations of Belleville boilers by the writer's firm described and discussed.

50.—*Iron Age*, "The Age of Nickel Steel." H. J. WILLIAMS.—Article favourable to nickel steel, and anticipating rapid extension of its use.

51.—*American Society of Naval Engineers*, "Relative Corrosion of Metals."—When exposed to salt or fresh water, wrought iron, wrought steel, and low nickel steel found to corrode about equally. High nickel steel only corroded about one-third as much as the above materials.

52.—*Institute of Civil Engineers*, "Recent trials of the Machinery of British Warships." A. J. DURSTON and H. J. ORAM.—Express boilers considered less economical than large tube type. The tubes of Belleville boilers last two commissions, unless in special cases, but those of express boilers have a much shorter life. Trial results of Belleville (with or without economisers), Babcock, and Niclausse boilers in H.M. Navy given. Zinc arrests corrosion, but only locally, and not effective near feed inlet, where wastage is rapid. Corrosion also caused by shore water containing lime salts, which form deposits. Tubes periodically examined and cleaned. If the diameter of a tube is found increased locally, the tube is replaced. The increase of boiler pressure had not caused serious extra trouble with the engines and fittings. Data given including a table shewing the saving in space and weight by the introduction of water-tube boilers.

53.—*American Society of Naval Engineers*, "Test of a Babcock & Wilcox Boiler built for the 'Alert.'"—Results of evaporative tests given, some of the trials with an air heater in the uptake, which, however, did not show any appreciable economic advantage over those made without the use of the heater.

54.—*Institute of Naval Architects*, "Trials and experiments made in H.M.S. 'Argonaut.'" A. J. DURSTON.—An account of the steam trials of the above cruiser, which is fitted with Belleville boilers of the economiser type. The particulars given have reference chiefly to the effects of cylinder jacketing, linking up, etc.

55.—*American Society of Naval Engineers*, "Boiler tube tests in the German Navy."—The specified requirements given complete. Tubes must be solid drawn Siemens Martin steel.

56.—*Institute of Mining Engineers U.S.*, "Properties and possible uses of nickel steel." D. H. BROWNE.—Full summary of the subject up to date. Nickel steel proposed for boiler material.

57.—*Institute of Marine Engineers*, "Effect of circulation in Water-Tube Boilers on evaporation." G. HALLIDAY.—Experiments described indicating that evaporation improved up to a certain rate of flow and then decreased. Author concluded that there is no advantage in a high rate of circulation. The tests were not made on actual boilers.

1900.

58.—*American Society of Naval Engineers*, "Practical data relating to the building of Bent-Tube Boilers." JOHN PLATT.—The process of manufacturing a Thornycroft boiler described.

59.—*Revista Marittima*, "Trials of Italian torpedo boat 'Condor.'"—Fitted with Yarrow boilers with closed ash-pit system of forced draught. Full power could not be obtained, and the system of draught was altered to the closed stokehold, with satisfactory results.

60.—*Boston Society of Civil Engineers*, "The economy of mechanical draught." WALTER B. SNOW.—The use of mechanical draught advocated as being more rational than sending heat up the funnel to create the necessary draught. The funnel temperature should be reduced and the heat utilized for heating the air or the feed water.

61.—*American Society of Naval Engineers*, "Corrosion of boiler tubes in the U.S. Navy." W. F. WORTHINGTON, U.S.—Oil and salt water should be excluded. Seamless steel tubes, with mill scale removed, should be used, and galvanized iron or steel internal fittings. Caustic soda or caustic potash should be added to the feed water and feed tank kept at about boiling point. Also the feed delivered into boiler above the tubes. Zinc plates recommended. Tubes now supplied are not uniform in quality, which favours galvanic action. Nickel-steel tubes expand about as much as brass, which might cause trouble. Suggested that surface of tubes might be case-hardened or enamelled in some cases. Experiments made with samples of tubes submerged in distilled water contained in a porcelain lined tank, a current of air being directed on to the samples. High nickel-steel was found to pit through as quickly as solid-drawn steel, though the general wastage was less. Suggested that in the manufacture of solid-drawn tubes, the billets should perhaps be bored and turned before being drawn into tubes, so as to avoid inequalities in the final result.

62.—*Admiralty Memorandum on Water-Tube Boilers presented to Parliament.*—Small tube boilers suitable for third class cruisers and smaller high speed vessels, but greater endurance desirable for larger ships, for which the Belleville is considered the "approved type." Experience obtained in the Navy with the Babcock and Niclausse boilers shows no decided advantage over the Belleville, but further trials on a larger scale will be made. Economy depends on the stoking, on keeping boilers free from deposits and avoiding leakages. List of troubles experienced with Belleville boilers given, which include corrosion, joints leaking, automatic feed gear failing to act, supports for back ends of tubes getting burnt, leaky washers, pitting of tubes, leaky safety valves; bursting, bending and burning of tubes, access of salt water, and smoke box doors warping. The Admiralty anticipate that all these difficulties will be quickly overcome as further experience with these boilers is acquired, and consider that much progress in this direction has already been made.

Comparisons given of the performances of vessels fitted with Belleville boilers and others fitted with ordinary boilers, the general conclusion reached being that the use of Belleville boilers adds about a knot to the speed of each class of vessel. The present boiler practice of foreign navies shewn to be favourable to the water-tube type.

63.—*Report of the Chief of the Bureau of Steam Engineering*, "Tests of a Babcock & Wilcox Boiler for the U S.S. 'Cincinnati' by Officers of the U.S. Navy."—Steam raised from water at 72 degs. F. to 215 lbs pressure in 12 mins. 40 secs. without injury of any kind to boiler. A series of tests made with and without an air heater in use. When burning 18 lbs. of coal per square foot of grate, the evaporation was 11·03 lbs. of water per lb. of combustible from and at 212 degs. F. without the air heater, and 11·51 lbs. with the air heater in use. With higher rates of combustion there was no appreciable advantage in the use of

the air heater, for example, when burning 31 lbs. of coal per foot of grate, the evaporative results were 10·49 with the heater and 10·41 without. The air was heated about 100 degs. F. in both the above tests.

64.—*American Society of Naval Engineers*, "Coal Consumption Tests of s.s. 'John W. Bates.'" B. C. BRYAN, U.S. Navy.—Tests were made in October, 1900, to note the action of mechanical stokers on the Babcock boilers of the above vessel, which were considered satisfactory. The total heating surface is 6000 square feet, the coal burnt at about 1400 i.h.p. being 1·5 lbs. per i.h.p. per hour, but at 1818 i.h.p. the consumption becomes 1·92 per i.h p.

65.—*Technical Papers.*—The accounts of trials of vessels fitted with water-tube boilers, and occasional articles, leaders, letters, etc. on the subject that have appeared in the leading technical weekly papers during the past ten years have also been consulted.

DISCUSSION.

Mr. CHARLES DOWSEN said the excellent paper they had just heard Mr. Griffith read deserved every engineer's attention; he had jotted down one or two things which he had noticed during his experience. The first point was that in the generality of small tube water-tube boilers there was not sufficient space above the fire for the proper combustion of the gases, and that, in his opinion, was one reason why they were not economical in the use of fuel, then if they turned to the large tube type they would find that, in addition to this defect, the circulation of the water seemed to have been in some cases entirely neglected, now in his opinion a boiler without a good circulation could not be a good steam generator nor yet a durable boiler. If they compared the ordinary or "Scotch" type of forced draught boiler in use in the mercantile service with a boiler of the "express" or small tube water-tube type reduced to a common basis of comparison they would find that the former had about 5 cubic feet of space for combustion for every square foot of grate area, whereas the latter in many cases had only $1\frac{3}{4}$. If any one could evolve a design of water-tube boiler which would remedy the defects mentioned he believed it would prove quite as economical as the "Scotch" boiler, although he was quite aware of the great difference at present existing between them, being in the one case $1\frac{1}{4}$ lbs. of coal and in the other 2 lbs. of coal per I.H.P. per hour. With regard to "express" boilers it must be borne in mind that the designers of such boilers must keep before them the necessity of getting the greatest amount of power out of them for a given space and weight, and no doubt other considerations were partly sacrificed to gain this end. The small tubes used are an outcome of this, and it

was quite out of the question, in his opinion, to expect such boilers to give satisfaction for ordinary use at sea, as the great amount of attention required to keep the feed water free from all foreign matter so as to avoid the chance of choking, &c., would require more people than are available in the case of an engine room staff of the average sea-going vessel. This brought them to the question of what would be the best diameter for the tubes in the future large-tube boiler, and it seemed to him that those engineers who had a wide experience of the large-tube boiler should give them the benefit of their opinion as to the smallest internal diameter advisable, if Mr. Griffith had thought the matter out it would be interesting to have his opinion on this point. He concluded by thanking Mr. Griffith for his paper.

Mr. WM. ALLAN, Junr., said although they did not all agree with Mr. Griffith as to the advantages of water-tube boilers, still he thought their thanks were due to him for his very interesting paper. He only proposed that night to deal with one or two points in Mr. Griffith's conclusion with which he disagreed. In the first place so far as increased mobility is thought to be obtained by use of water-tube boilers, all the the evidence before them pointed in the opposite direction, as H.M.S. "Europa," "Powerful," "Hermes," and others, with their enormous consumption and constant breakdowns, proved. Mr. Griffith said the subject had reached a stage that demanded the attention of all marine engineers. It had indeed reached that stage; for after three-quarters of a century of absolute failure it ought to be apparent that the water-tube boiler is, for sea-going purposes, in larger ships, useless, and it could not in any sense be termed a new development as Mr. Griffith called it.

It is 74 years ago since Steenstrup invented one of the first water-tube boilers for marine purposes, and from that date numerous inventors had invented water-tube boilers of every conceivable size and shape; each one in turn, when tried, proved a costly failure.

Seven years ago it was the Belleville boiler which was lauded throughout the country, and was adopted extensively by their Admiralty. Now the Committee appointed by the Admiralty, to investigate the cause of the constant failure of these boilers, condemned the Belleville boiler as unreliable, and added that they must not be fitted. This must inevitably be the verdict on all present day water-tube boilers as fitted into large vessels for sea-going purposes.

If Mr. Griffith would give a practical answer to the following questions it would show the members the true value of water-tube boilers for sea-going purposes :—

Why did Rowan's boiler, as fitted into S.S. "Propontis" 50 years ago, explode, killing several men?

Why did Jordan's boilers, as fitted into S.S. "Dakota" and "Montana," prove failures?

Why did Howard's boilers, as fitted into S.S. "Mark Anthony" and "Fairy Dell," explode, scalding several men?

Why did the Belleville boilers, as fitted into S.S. "Ohio," burst, scalding several men, and have to be finally taken out?

Why did the Babcock & Wilcox boilers, which we hear so much about, as fitted into the S.S. "Norman Isles," give so much trouble that they had to be taken out before she completed her first voyage?

The discussion was adjourned.

The following communications were received and taken as read :—

SPRINGFIELD, TALBOT ROAD,
OLD TRAFFORD, MANCHESTER,
March 28th, 1901.

DEAR MR. DUCKITT,

Mr. Griffith deserves to be congratulated on his paper, as both the subject matter, and the carefully compiled appendix is presented in such a form as to be readily digested up to date.

The time for such a paper is opportune, coinciding as it does with the issue of the interim report of the committee appointed by the Admiralty to examine into the suitability of various types of marine boilers for naval purposes. Between the Admiralty Committee's report and Mr. Griffith's paper there appears to be this similarity—that while neither recommend the Belleville boiler as a suitable type, yet some type of water-tube boiler is recommended as most suitable.

The Admiralty Committee do not arrive at their conclusion on the basis of increased economy of fuel, less cost of up-keep, better circulation, less leakage, or freedom from accident, in the case of water-tube boiler as compared with the cylindrical type. In all these respects the particular water-tube boiler under consideration is condemned "and the Committee are not prepared without further experience to say to what extent this may not apply to other types of water-tube boilers."

Referring to the advantages claimed for the water-tube boiler over "the ordinary boiler" it would be interesting if Mr. Griffith could give

the separate weights of the boilers and the contained water for comparative cases.

Granted that steam can be raised more quickly in the water-tube boiler, can it be maintained as steadily as in "the ordinary boiler" and which particular water-tube boiler is exempt from "the necessity of providing separators with automatic blow-out valves on the main steam pipes to provide for water thrown out of the boilers when speed is suddenly increased"?—(Admiralty report).

Admitting that "owing to the relatively small amount of contained water the damage caused by an explosion is less serious," are not explosions more frequent, and, in the aggregate, equally disastrous with, the water-tube boiler?

Mr. Griffith suggests a new method of comparing evaporative economies of boiler—with which I do not agree—but which would be all in favour of a light boiler, but he does not make it clear, whether the weight of the boiler only is implied, or weight of boilers plus contained water in each case.

I note in the Appendix—where the statements are often conflicting—that in no case is a greater economy of fuel claimed for the water-tube boiler than for "the ordinary boiler," but in Appendix (item 35*) where a comparison is given we have :—

	I.H.P. per ton of machinery.	Coal Consumption per I.H.P. per hour. lbs.
Gunboat "Wheeling" Ordinary Boilers	10·15	... 1·72
,, "Marietta" Babcock Boilers	9·34	... 2·18

As bearing on the low rate of combustion per square foot of grate area in water-tube boilers and the endurance of the tubes, I am informed by my brother who has run several voyages with tramp steamers fitted with water-tube boilers, where the tubes are only slightly inclined, that the firemen have to be carefully watched, because he had found that by making a thick hot fire locally, the tubes immediately above could be burnt out at will in a few minutes—the explanation given being that the direction of circulation of the water was interfered with, and the water simply "frothed" locally over the hot zone, and as a consequence the tubes were overheated and burst.

My own experience with water-tube boilers has been on land, and has not been in their favour as compared with ordinary cylindrical boilers.

My first experience, over 20 years ago, was with a "Roots" boiler fixed on top of a heating furnace, and arranged to be heated by the waste gases from the furnace and to supply steam to a steam hammer.

* Page 176.

The heating surface area as compared with a suitable cylindrical boiler appeared to be all in order, but when the hammer was started, a few strokes were sufficient to empty the boiler of both steam and water, although it was only necessary to fill the boiler again, and have steam blowing off in a few minutes ready for another start.

My second experience, 18 years ago, was with a "Howard's" boiler arranged to work at 80 lbs. pressure and supply steam to a laminated spring testing machine, working intermittently from 12 to 20 strokes per minute. The size of the boiler was considerably larger than necessary for the work, but immediately steam was taken to the press the water followed suit, and the feed (cold) introduced to make up the loss, cooled the boiler unequally and resulted in excessive leakage of joints. This boiler was replaced by a plain Lancashire boiler which did the work on less than two-thirds the amount of coal.

The above illustrations may be classed as ancient history repeating itself in the case of Belleville boilers with "water thrown out of the boilers when speed is suddenly increased."

During the last four years I have had similar experience with "Babcock" boilers and also with "Steinmüller" boilers—The former put down to supply steam for a horizontal compound condensing engine with cylinders 26 inches and 46 inches diameter × 5 feet 0 inches stroke running at 40-42 revolutions per minute, and driving sheet mills. The engine in question has a very heavy flywheel and is fitted with a sensitive automatic cut off gear arranged to admit steam to H.P. cylinder from 0 to about 70 per cent. of the stroke—the work on the mills being very irregular.

At each heavy pass through the mills, the cut-off gear responded to the demand for steam, and immediately after, the water, coming along with the steam from the boilers, streamed out at the relief cocks, piston rods and valve spindle glands.

This engine was fitted with the usual sight feed lubricator attached to H.P. valve chest, but the lubricant simply mixed with the water passing through the chest and did not prevent scoring of cylinders from want of lubrication.

The difficulty was in a great measure overcome by fitting steam traps at various points on the main steam pipe, and a large steam receiver at the boilers.

Similar experience had never been experienced with these engines in other parts of this country and abroad, working under precisely similar conditions, but supplied with steam from Lancashire boilers.

That steam can be raised very much more quickly in a water-tube boiler than in "the ordinary boiler" is readily admitted and that such boiler is lighter and has other advantages which "the ordinary boiler" does not possess is also clear, but at the same time "the ordinary boiler" has advantages not possessed by the water-tube boiler, and it would appear that a combination of the two types of boilers in one, indicates the direction in which true progress will be made.

Yours faithfully,

HENRY FOSTER.

15, VICTORIA STREET, LOUGHBOROUGH,
March 27*th*, 1901.

DEAR MR. DUCKITT,

I think Mr. Griffith is to be congratulated on his paper; it is very impartial all through and leaves all the hard hitting to be done by those discussing it. His definition of "express" and "large tube" boilers is not very comprehensive. For instance, Babcock make (I do not know whether they still continue to do so) a small tube boiler with the tubes slightly inclined to the horizontal. The tubes I saw were about $1\frac{1}{2}$ inches inside diameter.

I enclose herewith a design for a boiler (Plate XIV.) with vertical water tubes of comparatively large diameter ($2\frac{1}{2}$ inches outside diameter), which does not come under Mr. Griffith's definition. A more convenient definition of the various types would be to divide them into two classes: 1st, Those whose water tubes are vertical or nearly so; and 2nd, those whose water tubes are horizontal or nearly so. I can only call to mind one boiler which would not come under one or other of these divisions, viz., the "Haythorn" boiler.

The above definition eliminates the term "express," a term of very little meaning. In comparing a fire tube and a water tube as regards evaporative duty, it should not be forgotten that it is much easier to clean the *inside* of a tube (provided that it be straight) than the outside. In the case of a fire tube the inside will get dirty first from deposit and accumulations of soot. A few minutes with a tube brush will effectually clean the whole internal surface. The outside of the tube will only be affected by deposits from the feed water, and cleaning at long intervals will suffice.

With the water tube on the other hand it is difficult to get a tube brushed all round its exterior surface when it forms one of a nest. I think this point about the cleaning externally of water tubes has not been sufficiently emphasized in the paper.

It is well known that Belleville boilers, when in actual service, burn more coal than the ordinary boiler, although the results of Belleville coal consumption trials show a marked economy over the ordinary boiler. As we know that the tubes of the ordinary boiler can easily be kept clean when under steam, and that it is impossible to do the same with the Belleville, it appears likely that the loss of efficiency is due to dirty tube surface. This defect is common to all boilers of the horizontal tube type. A steam jet is used in many cases, but it is very ineffective, a wire brush or scraper being the only thing to really clean the surface.

Referring to the inherent objections to water-tube boilers, No. 3 is perhaps the most serious, viz., a leaky tube cannot be plugged without putting the boiler out of service. In the case of a small leak the fire tube can be plugged while the boiler is under steam. In the case of a large leak, however, such as a split tube, it would be necessary to shut down the boiler in either case and put in a tube stopper. The fire tube (which will have collapsed) will need to be opened out by a drift to pass the tube stopper, but the water tube (which will have burst) will naturally pass the tube stopper.

Passing on to the question of economy, I think Mr. Griffith's suggestion of basing the comparison on weight of boiler would be most unfair to the ordinary boiler. The weight economy should be kept distinct from the thermal economy, otherwise a badly-designed but light water-tube boiler would be rated above a well designed ordinary boiler. I think a better suggestion would be to specify a certain consumption per square foot of heating surface, and the best boiler would evaporate the most water per lb. of combustible. The weight economy should be treated separately.

I am glad to see Mr. Griffith take up the question of combustion space. The combustion chambers of all the horizontal tube type of boilers are, even when of sufficient volume, not sufficiently high, and good combustion, except with very careful, frequent, and easy firing, is an impossibility. It may be said truly that nearly all the horizontal tube types as made are totally unsuited for forced draught. The Belleville boiler affords a good example of that dogged persistence which is supposed to be so essentially British, and appears in this case to be shared by the French. The boiler, as originally made, worked very well when not pushed, and the trouble began when it was put to work at a rate higher than it was probably designed for. The combustion chamber was found to be too small. The designers did not alter the original design, but put in special blowing engines to deliver jets of air

under pressure to the combustion chamber. This was found to be unsatisfactory and the tubes were divided into two sets with an auxiliary combustion chamber between them, also fitted with air jets. This arrangement has just been condemned by the boiler committee, who recommend a reversion to the single combustion chamber, but made *higher*. The boilers were found to give very wet steam ; the design was not altered, nor the steam drum made larger, but the boiler pressure was made 50 lbs. higher than that used at the engines, special throttling valves being provided to reduce the pressure and dry the steam as much as possible. This was not entirely satisfactory, as, on a sudden increase of engine speed, the steam pipes and cylinders were liable to be flooded with water. No alteration was made to the design but special automatic separators were put in the steam pipe to deal with this water. There was a difficulty about the water gauges on account of their not showing a true water level, resulting in many burnt tubes. This was got over partly by a very ingenious and special feed regulator.

For some reason which I have not been able to fathom, it was found necessary to work the feed water at about twice the steam pressure. For this, special pumps of Belleville design have to be used. The circulation in the water tubes was always inferior, resulting in over-heated and distorted tubes. The old design was manfully stuck to, but a special make of tube, the material of which can only, I believe, be obtained in Sweden, is now used. These tubes, with good luck, may last one voyage. Now, this shows magnificent pluck, but is it business-like? It has been a good piece of business for the Belleville people, but not for the British taxpayer. The amount of royalty paid them (the Belleville Co.) up to date is rather startling.

With respect to the means of properly distributing the gases over the heating surface, I should think the tortuous circuit with the small cross-section would be by far the most efficient. Even with the return tube boiler (whose gases travel a long distance) Howden has found an advantage in using retarders in the tubes. If the tubes are vertical they will take no harm provided they get a good supply of water circulating through them.

Coming now to the question of circulation, Mr. Griffith very rightly points out that the horizontal tube type will not stand forced draught, and the question arises, which is to be discarded, forced draught or horizontal water tubes? It is not at all likely that forced draught will be given up now because a particular type of boiler will not stand it. The only rational conclusion to come to is that horizontal tubes are

quite out of date. The deterioration of tubes in the Belleville boiler has been so rapid and so contrary to the experience with fire tubes doing the same evaporative duty that, in view of the known fact that with forced draught the circulation is defective, there does not seem any room for doubt that the cause has been in nine cases out of ten due to over-heating and not to defective welds, inequality of material, etc., and other such excuses. The deterioration in vertical small tube boilers is probably due to the same cause, as it is quite conceivable that a tube of small bore, such as is used in this class of boiler would, even though vertical and with free opening at each end, be liable to be filled with steam only if the evaporation were very heavy.

One other advantage possessed by the vertical water tube is that the steam discharged from any one tube does not interfere with the discharge from any of the others. The same thing applies also to the entrance of water into the bottom of the tubes.

In the case of the Niclausse and Durr boilers, the steam from the lower tubes has to baffle its way in a narrow header through all the other streams of steam discharged by the upper tubes. Besides this, the upper tubes get the better chance for a good flow of water, and they require it least, whereas the lower rows have to take what they can get.

Yours faithfully,

W. R. CUMMINS.

EAST COWES, I. OF W.
March 26th, 1901.

EDWIN GRIFFITH, Esq., Wb. Sch.

DEAR SIR,

By the courtesy of the Secretary of the North East Coast Institution we have been supplied with an advance copy of the very interesting paper you are about to read before the members of that Institution.

As we have been interested in the construction of small tube water tube boilers for some years we venture to enclose you various particulars of a boiler (Plates XV. and XVI.) we are now constructing, as it appears to embody, in a marked degree, features to which you give favourable consideration in your paper. We constructed Blechynden boilers under a license for some time as we recognised that it possessed inherent advantages over any other boiler then in the market.

With a view to simplicity, particularly in the direction of spare tubes and the abolition of a line of screwed plugs or hand holes along the top of the steam drum, some of which hand holes being of necessity under

the base of the uptake, we introduced the boiler of which a diagram is enclosed. All tubes are identical in radius, there is a slight difference in length only. The points of the boiler can be readily followed by the assistance of the enclosed notes, and the curve of results (Plate XVII.), which to eliminate differences of ratio of $\frac{Gs}{Hs}$, has been referred to a unit of heating surface. Our baffles do not interfere with cleaning and further tend to protect the outer casings from the fiercest flame when driving at high rates of combustion.

We agree with your remarks and comparisons as to superiority of small tube "express" type over any large-tube boiler made, and feel that the water-tube boiler of the future will contain more of the "express" and less of the existing large tube features.

We are inclined to doubt if the present tendency towards fitting larger diameter tubes next the fire in "express" type boilers should be followed without grave consideration. It is extremely probable that advantages would accrue from putting, say 1¼ inches tubes next the fire, where the bulk of the tubes as well as those next the fire had originally only been, say 1 inch diameter, but probably better results still would be obtained (I mean as regards endurance under *all* conditions of Naval Service) if *all* the tubes had been made 1¼ inches. If the tubes next the fire are large enough and *only just large enough* to stand the maximum condition of steaming they would seem much more likely to give ultimate satisfaction than would rows of tubes which do the *maximum* steaming very easily, and therefore circulate slowly at reduced rates of steaming.

Deposits are formed when the boiler is "stewing" or steaming slowly, because of the sluggish circulation under these conditions, and the life of the boiler in the Navy probably contains on an average about 80 per cent. of its steaming days under considerably less than maximum conditions.

It should therefore be carefully watched that by increasing the diameters of the rows of tubes next the fire we are not inviting, under some conditions of steaming, a sluggish circulation in those rows and therefore deposit. We have experimented with retarders and obtained an improved evaporation of 12 per cent. due to them, and if large tubes are to be fitted next the fire, spiral retarders, by reducing the area and ensuring good circulation from their shape, would seem a necessity. In our boiler these retarders can be readily lifted from the tubes for examination, and would generally indicate what the internal surfaces of the tubes were like as regards deposit. They might be made of zinc

with advantage if internal corrosion, not due to overheating, was suspected. We have made this feature (retarders, &c.) a subject of a patent. The baffles or divided uptakes are also a patent feature of our boiler.

We are sending these particulars to you *via* Mr. John Duckitt, and trust you will excuse us inflicting them on you, but we are aware that owing to non-advertisement our boiler is not well known outside the immediate users, and seeing that you are evidently interested closely in the subject we thought you might like to know what is being done here.

We are, Sir,

Yours faithfully,

EDW. C. CARNT,

for J. S. WHITE & CO., LTD.

SMALL TUBE WATER-TUBE BOILERS.

SPECIFIED CONDITIONS INTRODUCED INTO ADMIRALTY SPECIFICATION IN 1895-6:

"It is important that the design of the boiler should be such as to admit of each and all the tubes being withdrawn and replaced readily without disturbing the boiler itself, bulkheads or other permanent fittings, and to admit of the tubes being readily swept. Facilities to be provided in the water chambers to which tubes are fixed for cleaning out such chambers and for making the lower tube ends tight. The curvature of the tubes should not exceed that which will allow of a wire brush being passed through them from end to end."

COPY OF ADMIRALTY LETTER S. 19307, 16992—Dated 20th August, 1900:

"In view of the experience gained in respect to the shortening of the life of tubes in small tube water-tube boilers, in which the tube end is reduced in internal sectional area at the tube plate, I have to inform you that in future, designs which embody tubes with ends so reduced will not be accepted.

2. In submitting designs for small tube boilers, bends in tubes of less than 1 foot radius and bends of reversed curvature should be avoided."

WHITE-FORSTER BOILER BUILT UP ON ABOVE—FIRST CONSTRUCTED MARCH, 1898.

GENERAL DESCRIPTION OF THE WHITE-FORSTER BOILER (See Plates XV., XVI. and XVII.):

(1.) It is a drowned tube boiler.

(2.) The tubes are curved sufficiently to determine the direction in which they will move when subjected to heat.

(3.) All the tubes are curved to the same radius (simplifying spare gear).

(4.) The tube holes are converged so that the tubes (produced) all intersect and fall within the space which would be swept out by the manhole passing from end to end of the top drum.

(5.) The upper tube ends face the manhole and any one tube can be removed and replaced through this manhole without any greater difficulty than is experienced in removing and replacing a tube in a smoke-tube boiler.

(6.) A rigid tube brush can be used with effect in sweeping the tubes as the long axis of the top drum is available for working in, instead of the diameter only, which latter condition usually obtains in all other small tube boilers.

(7.) The top drum is necessarily of ample dimensions to admit of the tubes being drawn through it and yet can be smaller for the same length of tube, than any other design of boiler which withdraws the tubes into the top barrel.

(8.) An ordinary internal steam pipe with saw cuts is all that is required to ensure dry steam at the cylinders. We have never in rough weather with engines running at 530 revolutions (in fast Vedette Boats) had to ease the engines for priming and have no record of priming. The reason appears to be that the foaming water is deflected and kept down by the direction of the out-let from the tubes.

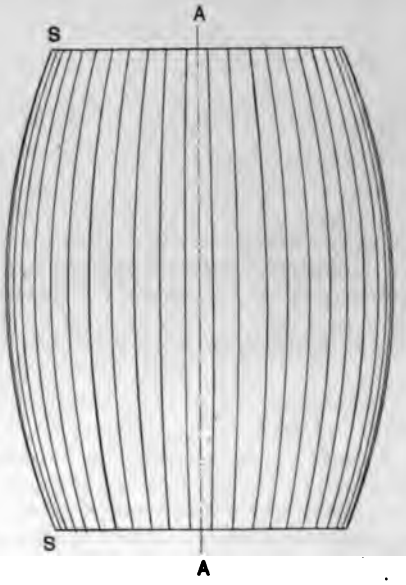

FIG. 5.

(9.) We adopt a divided uptake which in actual practice is seen to cause the gases, on their way to the funnel, to dip down and embrace the lower half of the tube surface, the area on the inner side of the uptake not being sufficient to allow the gases to escape when using say 1½ inches to 2 inches air pressure and upwards. This uptake arrangement is patented and can be modified to suit various conditions.

(10.) The front casings are fitted with doors which can be removed, exposing the whole length of the tubes for cleaning.

(11.) The boiler can be thoroughly opened out for inspection and cleaning by any ordinary fireman and can be closed up again by the same man without any assistance from a skilled mechanic. This, we maintain, is not the least important point, as satisfactory working can only be obtained by rendering the boiler easily understood and easily managed by the fireman who has to work it

The sectional view of the boiler seems to contradict the clause marked (3) hereon, but as we have generally had to explain specially this apparent contradiction, we take the liberty of doing so now.

If we look at an ordinary beer cask, built with staves and hoops, we see that each stave is bent to the same radius. If we cut this cask into sections vertically through A A (Fig. 5), we note that the stave through which line A A passes is, in elevation, apparently quite straight, while the staves as they approach the side S S appear to be more curved. Yet are they all the same radius.

It is now readily seen how the section of the boiler resembles the cask. The tubes, although curved to the same radius, take up in each row positions due to the converging of the tube holes as if they had been rotated round their ends through a small arc. Every tube therefore takes its share of the stresses in the boiler equally, and it is a matter of remark that there is absolutely no deflection under severe water pressure test conditions. In raising steam the drums change their relative positions very slightly (about 1/32 in an average boiler) up to the point of pressure showing. After that up to 200 lbs. pressure no further changes occur.

We fit no stays between the top and bottom barrels. The curved tubes "hook" the tube plates altogether and we claim it is the most rigid boiler built.

Since March, 1898, we have built the following:—

	Complete.	*In Hand.*
For the British Government	42 ...	10
,, ,, Japanese ,, ...	6 ...	2
,, ,, Austrian ,, ...	2 ...	1
,, ,, Russian ,, ...	0 ...	1
,, ,, Royal National Lifeboat Institution. Steam Lifeboat	2 ...	1
	52	15

They range in power from 100 I.H.P. to 1,000 I.H.P., and we have three of the latter power under construction now.

Under severe conditions of inspection by the British Admiralty Staff, boilers of various sizes have been subjected to evaporative tests, the boilers being placed in a closed test house on shore and an air pressure maintained by a large fan delivering into the house. The results plotted on the enclosed curve have been recorded.

In order to eliminate the different ratios of grate to heating surface which must always obtain in boilers designed to suit different dimensions and conditions of vessels, the results are referred to a unit of heating surface which will be readily understood from the diagram.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SEVENTEENTH SESSION, 1900-1901.

PROCEEDINGS.

SEVENTH GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE SUNDERLAND LITERARY SOCIETY, SUNDERLAND, ON FRIDAY EVENING, APRIL 26TH, 1901.

HENRY WITHY, ESQ., J.P., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, held in South Shields, on March 29th, 1901, which were approved by the members present, and signed by the President.

The ballot for new members having been taken, the President appointed Mr. D. Andrew and Mr. John H. Heck to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Armstrong, Adam Latimer, Shipbuilder, 3, Bells Terrace, North Shields.

Berven, Ferdinandt, Ship Draughtsman, c/o Messrs. Bergens Mekaniske Værksted, Bergen, Norway.

Hamilton, Andrew, Consulting Engineer, 19, James Street, Liverpool.

Mackley, Edward N., Engineer, 97, Enfield Road, Elswick, Newcastle-upon-Tyne.

Stephens, Thomas S., Engineer, 16, Archbold Terrace, Jesmond, Newcastle-upon-Tyne.

Torrance, Robert Patterson, Chemical Engineer, Heworth Old Vicarage, Felling-on-Tyne.

GRADUATES TO MEMBERS.

Adamson, Chas. P., Engine Draughtsman, c/o W. Kinnaird, Esq., 175, Great Junction Street, Leith.

Swinburne, Matthew, Ship Draughtsman, Frazer Terrace, Heworth, Felling-on-Tyne.

The PRESIDENT announced that in accordance with Article X. of the Constitution, the following gentlemen retired from the Council :—*President*—Mr. Henry Withy (eligible for re-election) ; *Vice-Presidents*—Mr. George Clark (deceased), Mr. Arthur Laing (deceased), and Mr. W. J. Bone (retired) ; *Hon. Treasurer*—Mr. G. E. Macarthy (eligible for re-election) ; *Ordinary Members of the Council*—Messrs W. Hök, W. C. Mountain, H. B. Rowell, A. G. Schaeffer, G. W. Sivewright (not eligible for re-election).

In accordance with Bye-Law 11, the PRESIDENT on behalf of the Council nominated the following gentlemen to be balloted for to fill the vacancies, and intimated that members could add to the list :—*President*—Mr. Henry Withy ; *Vice-Presidents*—Mr. W. Hök, Mr. H. B. Rowell, Mr. A. G. Schaeffer, and Mr. G. W. Sivewright (three to be elected); *Hon. Treasurer*—Mr. G. E. Macarthy ; *Ordinary Members of the Council*—Mr. E. W. De Rusett, Mr. J. H. Heck, Mr. R. Home Muir, Mr. J. C. Sirzaker, Mr. Henry Walker, and Mr. G. Dobie Weir (five to be elected).

Mr. D. ANDREW proposed Mr. Robert Wallis (Messrs. Wallsend Slipway and Engineering Co.) as a Member of Council.

Mr. G. M. BROWN's reply to the discussion on his paper on "The Efficiency of Marine Boilers" was read by the Secretary.

The discussion on Mr. E. Griffith's paper on "Water-Tube Boilers" was resumed.

Mr. J. M. THORNTON read a paper on "A Simple Method for Preventing the Corrosion of Tail Shafts."

MR. G. M. BROWN'S REPLY TO THE DISCUSSION ON HIS PAPER ON "SOME ATTEMPTS TO INCREASE THE EFFICIENCY OF MARINE BOILERS."

Mr. G. M. BROWN wrote from Hull, regretting that he could not be present, as he intended, to reply in person to the discussion; but sent the following communication, which was read by the Secretary :—

Before replying to the discussion on my paper I must thank the members, who have taken part therein, for their reception of it. It was written at very short notice and is perhaps not so complete as it might be. In writing it I considered only the abstraction of heat from the products of combustion, and therefore did not include any notice of the increased efficiency obtained by the use of feed-heaters supplied with steam either from the boiler or some part of the engine; neither did I take into account the effect of the human factor.

Mr. Henderson's remarks anent the corrosion in feed-heaters, or as they are often called, economisers, were very much to the point, and it is to be regretted that a successful heater of this type has not yet been produced. While agreeing with him as to the necessity of extracting the air from the feed-water and thoroughly neutralising it before admitting it to the heater, I consider that the commercial success of the apparatus for this purpose is not a matter to be decided off-hand; if such apparatus were used in conjunction with a feed-heater I think its cost of upkeep, etc., should be combined with that of the heater in calculating the actual saving effected. Mr. Henderson's remarks on the use of superheated steam were most interesting, but are not Continental engineers getting ahead of us in this matter? In one installation of 7,000 H.P. on the Schmidt system steam of 150 lbs. pressure with a temperature of 358 degs. Fahr. is superheated to about 620 degs. Fahr., the steam consumption is from 10 to 11 lbs. per indicated horsepower per hour, and the engines are said to give no trouble. An engine exhibited by Messrs. Stork, Freres et Cie at the Paris Exhibition is designed for use with steam superheated to 788 degs. Fahr., which is, however, cooled down to 662 degs. Fahr. before it reaches the high pressure steam chest. In this case there is no piston rod packing and the valve spindles are fitted with special hard cast-iron rings. Messrs. Robey also have engines running successfully with steam superheated to 600 degs. Fahr.

Mr. Borrowman takes exception to my use of the word "attempt," but I can assure him I do not by any means consider it synonymous with the word failure. There is a saying: "Something attempted, something done," and in the case of Mr. Borrowman's firm there can be no doubt that very much has been done towards increased economy. If the efficiency deduced from the Newcastle experiments can be taken as a criterion of the performances of the old fashioned rectangular boiler, it would not appear that there has been any increase in the efficiency of the ordinary type of marine boiler, but rather the reverse, for according to the results obtained by the Marine Committee of the Institution of Mechanical Engineers, the boiler efficiencies of two ships fitted with natural draught were 62 per cent., and the average for three ships fitted with forced draught was 67·1 per cent. Unfortunately in very few of the older experiments was the efficiency determined, and there is thus some difficulty in forming an opinion on this point. Mr. Borrowman gives some useful figures relative to the increase in economy due to feed-heating. From the table of temperatures he gives it will be seen that the products of combustion are actually rejected at a temperature of 400 degs., which is above the average for stationary practice. The first stage of the feed-heating might be effected by utilizing this waste heat, instead of by means of a contact heater, provided the corrosion difficulty could be overcome. I am not prepared to admit that the fitting of retarders is simply a matter of guess work, but of course in the case of Scott's Economizers it would be difficult on the data at present available to formulate a rule for the outlet area of the various rows of tubes. In fitting these retarders, due attention is paid to the design of the boiler, and as far as possible to the nature of the fuel. There is no doubt, as Mr. Borrowman points out, that if a boiler could be designed in which combustion would be wholly completed before the gases entered the tubes, and the tubes themselves were of small diameter, and so arranged that the products of combustion were properly divided among them and passed through them with a high velocity, retarders would hardly be necessary, but I consider that until a boiler with small tubes that will work satisfactorily for long periods can be produced, some form of retarder will generally be found beneficial.

Mr. Hodgson's remarks on the difficulty of securing an efficient lubricant for the pistons and rods of engines using highly superheated steam were interesting, and it is to be hoped that this difficulty will soon be overcome. A paper from some member who has had experience in this direction would be of great value.

I do not agree with Mr. Shute that the 5 per cent. loss by radiation should be deducted from the heat of the waste gases in the chimney; after the gases leave the boiler any radiation from the uptake simply dissipates heat already lost, and only has the effect of slightly diminishing the draught. At the same time, I must express my indebtedness to him for his remarks on the difficulties encountered by M. Audenet; it is much to be regretted that the boiler used by that gentleman was not constructed in accordance with his designs. The Scotch boiler, as usually fitted, may be reliable and easy to keep up, but would it not advisable to use a more efficient piece of apparatus, even if it were a little more complicated? The answer to this question will be found in the results obtained from such installations as those of the "Inch" line.

Mr. Atherton has given a clear definition of the efficiency of a boiler and has summarised in a masterly way the various methods of increasing it. With regard to the heat wasted by imperfect combustion, all the analyses of the chimney gases of marine boilers I can find show that combustion is practically complete as a rule, but the question is, is it completed before the gases reach the smoke-boxes? In tabulating the results relating to varying grate area, Mr. Atherton has not given the ratio of heating surface to grate surface. The heating surface of the boiler itself was 749 square feet, and of the feed-heater 320 square feet. He also cites some experiments mentioned in Sennett and Oram's book on "The Marine Steam Engine," but I do not regard the results there given as in any way complete. Certainly a diagram is given shewing the temperature gradient in one tube, but no information is given as to its situation. Similar results were given in a paper read by Sir A. J. Durston before the Institution of Naval Architects, in 1893, and in this case the temperatures were only measured in the centre tube of each combustion chamber. These measurements give valuable information as to the temperatures existing at various points in a marine boiler, but do not afford any means of determining the difference of temperature which there is good reason to believe exists, say, between the upper and lower rows of tubes, nor do they give the slightest indication of the relative amounts of the products of combustion which pass through the various tubes.

Mr. Atherton has given an interesting table of the results obtained from a Belleville boiler with economiser. As my paper was on *the* marine boiler, *i.e.*, the Scotch boiler, I did not think it advisable to include any such figures, and, therefore, merely remarked that feed-

heaters of the economiser type were coming into use with such boilers. The definition of economy given by Mr. Atherton is very much to the point, and expresses well the idea of economy which should be always with the constructive engineer. As to the propellers of the Cross Channel steamer, I am sorry I have no information.

I entirely agree with Mr. Heck as to the great value of Mr. Wye William's work. Mr. Heck seems to have a very poor opinion of the ordinary method of testing boilers, and the method of determining the calorific value of coal which he favours is hardly likely to be very correct. I wish to point out that I did not say *no* gain in efficiency is likely to be made by increasing steam pressures, but that no considerable gain is likely to be made in that manner, *e.g.*, no gain comparable with that obtained by using highly superheated steam. At present it seems that further advances will be made in the direction of increasing the pressure and using more highly superheated steam, but I submit that before we can proceed very much further some alterations will be necessary in the design of our engines and boilers.

The PRESIDENT said he was sure they had listened with great interest to Mr. Brown's reply following a very valuable paper and discussion. He asked them to pass the usual vote of thanks to Mr. Brown for his interesting paper.

The proposal was carried by acclamation.

RESUMED DISCUSSION ON MR. E. GRIFFITH'S PAPER ON "WATER-TUBE BOILERS."

Mr. J. H. HECK said this was a good paper on a very interesting and important subject. He would entirely confine his remarks to the question as viewed from the mercantile marine. Mr. Griffith raised the query if it was the best to put the water outside or inside the tubes. Mr. Heck thought that a great many connected with the mercantile marine would answer outside, there being a general opinion that the ordinary Scotch boiler at the present time made most money and dividends. There were two opinions felt by many engineers that the average water-tube boiler was not so economical nor so durable as the ordinary cylindrical Scotch boiler. In most water-tube boilers the grate area was too large to be properly fired for long periods. That was one of the causes of loss. Again, in the same way as flame will not pass through wire gauze, so in water-tube boilers with tubes so close together a very great economical result could not be expected. Mr. Heck considered that if water-tube boilers were used they should be large for the work to be done, greater sub-division of grate area, perfect workmanship, and larger steam and water drums, so as to increase the area of the water level, and the quantity of water tubes should be spaced farther apart, and better arrangements should be made for clearing the tubes from soot and dirt. With regard to the durability of water-tube boilers, Mr. Heck stated that if such boilers were to last, the scantling of the details should be increased, and just as the water from the hotwell was pumped into the boiler through filters, so it was also necessary to purify the water actually in the boiler, and one way of doing this was to have a small pump to draw the water from the boilers and pump it through filters back again into the boilers, or a small pipe could be led from the boilers to the feed pumps for the same purpose.

Mr. A. GRAY said he was pleased to have an opportunity of referring to Mr. Griffith's valuable paper, and must congratulate him upon his moral courage in bringing the "innovation" before them. He (Mr. Gray) was not going to tell them how to make a water-tube boiler or refer to the workmanship, although good workmanship was as essential to it as to any other; but what he had to say was from six years' experience in running them, in particular the Babcock & Wilcox boilers. He did not think that they as engineers had very much to boast about, seeing that water-tube boilers could be run ashore so easily. He remembered some

years ago they had a Roots water-tube boiler at Messrs. Blair's, of Stockton, fixed above a forge furnace, which ran for many years; they had no trouble, it neither burst nor bent the tubes. If it had not been moved for alterations it might have been running yet. Now it had been decided to continue fitting water-tube boilers in the Navy, and no doubt they had many good points which Mr. Griffith had told them of, and he felt assured if engineers would take the matter in hand, there was a great future before them in the marine world. He quite agreed with Mr. Griffith's remarks upon the difficulty of keeping salt water out of the boilers. Therefore a water-tube boiler should be made a cleanable boiler, or its life would be short. With all the rapid circulation referred to, they still got scale in the tubes. As regarded large or small tubes, he had had under his charge some boilers with $1\frac{3}{4}$ inch and others 4 inch tubes at the lower part and $1\frac{3}{4}$ inch at the upper part. They had had less trouble with the large tube. That might be because there were fewer to keep clean, and they were certainly easier to examine internally. They did not carry a spare boiler to clean at sea as Mr. Griffith suggested. As regarded the cleaning, the Babcock and Wilcox boiler was not so difficult as they might think. If they scraped the tubes before the scale got hardened, or possibly some water left in them, they could have the lower tubes of the Babcock boiler scraped, washed out, and boxed up ready for sea before they could get inside the ordinary boiler. It was the bottom tubes he referred to, the upper ones did not require cleaning so often. In regard to the regulation of feed supply, they used the ordinary type feed pump as fitted on the engines, and had no trouble. They carried only 200 lbs. of steam. All their boilers were fitted with steam drums, but they were not fitted with separators, and they had no difficulty or trouble with priming. The question of economy depended much on the firing. They got men accustomed to pitch coals into a fire and thought it sufficient. Now they had 50 to 60 square feet of fire grate to work, which required a thin fire of about equal thickness, but instead of this they piled on the coals and got thick fires and thereby wasted coals. Now as to oil and air passing into the boiler with the feed-water: in his opinion that was the greatest enemy to the water-tube boiler. He found quite thick salt scale on the tubes, not so bad as a very thin, oily scale, however, but the tubes blistered and burned into holes. Mr. Griffith referred to a system (Fig. 4 page 167) for trapping the oil and other impurities inside the boiler. Mr. Babcock tried something nearly similar some years ago. He never saw anything in traps. The sediment was so fine and light after passing the filter, it would not settle down with the circulation or movement of the water, and passed through the tubes. When

Messrs. Babcock and Wilcox were fitting in this trap system he thought it was a waste of time and money, and he was then under the impression they got pure, clean water from the surface condenser. But on experimenting he had found it quite the reverse, and that quantities of oil and other matter passed the filter. Mr. Yarrow, a great authority on water-tube boilers, in a paper he read before the Institution of Naval Architects in 1899, on the endurance of the Tubes of Boilers, said the deterioration was probably owing to the action of acid in the boiler water through grease, which in spite of every precaution found its way into the boiler. He had come to the same opinion himself after the trouble they had had with the tubes. He was not chemist enough to speak with authority, but he thought the oil was mixed in the feed-water like cream in the milk. The ordinary filter did not separate it. He had come to the conclusion that such injurious matters did get into the boiler, and he had been trying for some time to scheme a plan of extracting them from the feed-water after it had entered the boiler, before it mixed in the boiler water. If they would allow him a few minutes he would show them the system he had adopted, and also the sediment and other impurities extracted as well as their analyses.

Mr. Gray here produced two bottles containing water, oil, and sediment, of which the following was an expert analysis :—

LABORATORY AND ASSAY OFFICE,

DEAR SIRS, NEWCASTLE-ON-TYNE, *February 28th*, 1901.

We have analysed the samples of water and deposit from tube boilers received from you on the 13th and 19th February. The deposit was found to consist of the following ingredients after being dried at 212 degs. Fahr. :—

	Per cent.
Peroxide of iron	9·86
Protoxide of iron	1·35
Oxide of copper	0·33
Alumina	4·19
Oxide of zinc	1·50
Zinc	1·57
Magnesia	24·50
Alkalies	1·11
Sulphuric acid (combined)	0·69
Chlorine (combined)	0·90
Combined water	22·30
Free oil	12·32
Combined fatty acids from oil (existing as soap) ...	1·88
Siliceous matter	17·60
	100·20
Less oxygen of bases combined with chlorine ...	0·20
	100·00

The clear water of sample was analysed and found to contain as follows in grains per gallon :—

	Grains.
Chloride of sodium	345·72
Chloride of calcium	trace
Chloride of magnesium	46·08
Sulphate of lime	24·11
Free oil	0·80
Combined fatty acids from oil (existing as soap) ...	1·40
	418·11

The free or uncombined oil in the deposit seems to have been entangled and carried down with the deposited matters.

(Signed) J. & H. S. PATTINSON.

Mr. Gray, continuing, said the stuff in the bottles had been taken out of a separator which might have had 20,000 gallons of water passing through it to leave the said deposits. It was a mystery where much of it came from, because they used no oil in the cylinders and had not done so for years. They only swabbed the rods. All this water was passed through a Rankine filter before it went into the boiler. They saw there was salt mentioned. Well, those ships did not carry a supply of fresh water, and had to pump salt water. (Mr. Gray had invented a mechanical device for intercepting or extracting the finer impurities from the boilers, a drawing of which he described. See Plate XVIII.) Proceeding, he said they could all enumerate failures that had occurred, tubes bursting, and other serious accidents, but, as engineers, they had been slow in devising any improvement in the treatment for preventing these failures in the future. They kept following no particular groove, and as long as they were running them under the same conditions they could not expect any improvement. It was quite evident now they could not run a water-tube boiler under the same conditions as ordinary boilers with only six or seven tons of water instead of twenty-five or thirty tons. Without some plan such as he had shown them to separate the oil and other impurities from the feed-water, or some other system as good or better being adopted for preventing the contamination, the pollution was ruinous and the deposit dangerous inside the tubes. He was afraid the water-tube boilers could not be run with success by the old system of treatment. Since they had put this apparatus into the the boilers they had not had any trouble. It did not make bad tubes good ones, but the tubes with any life in them had not taken any harm since they adopted this system.

Mr. Gray wished to explain in regard to his exhibit that the sediment was taken out from, perhaps, 20,000 gallons of water put into the boiler, and the clear water had to come out of the bottom of the vessel, and the sediment was taken from the top by small scumpipes after it was heated, but it was not mixed amongst the water in the boiler.

Mr. J. R. FOTHERGILL (Vice-President) said he had listened with very great interest to the remarks of his friend Mr. Gray. He had also been interested in Mr. Heck's remarks, but he felt a certain amount of disappointment in what Mr. Gray had told them. He fully recognised that Mr. Gray was a gentleman of very great practical experience, one who was able to judge and form sound and judicious opinions, but he (Mr. Fothergill) had rather failed to gather from Mr. Gray's remarks wherein the water-tube boiler, as a boiler, had failed. Mr. Gray had said a great deal about the difficulty he had experienced as to objectionable and deleterious matter which, in the feed-water, entered the boiler, either corroding or forming a scale or deposit on the interior parts, more especially in the tubes, to their destruction; but Mr. Gray distinctly admitted when the entry of such deleterious matter into the boiler was prevented, they experienced no difficulty, and thus his (Mr. Fothergill's) reason for saying he was at a loss to understand wherein the water-tube boiler, as a boiler, was a failure. If it was admitted deleterious matter could not be kept out of the boiler, and he certainly was under the impression few engineers would be prepared to make such an admission, he then understood Mr. Gray's reason for condemning the water-tube boiler, but would not the same conditions be detrimental to the Scotch boiler? In confirmation of his contention, Mr. Gray showed them bottles of deposit taken from the boiler, and also gave an analysis of the deposit and water in the bottles. That was most interesting, but, before he could form any useful opinion as to the deleterious effect of the deposits shown, he must ask Mr. Gray what percentage was the deposit to the whole of the feed-water supplied to the boiler? It was manifest that a quantity of deposit which might be a very serious matter say in 100 gallons of water, could be ignored in 10,000. Although the percentage of the various ingredients of the deposit to the quantity of deposit might appear very formidable and alarming, yet, as a percentage of a large body of water, they might have little or no deleterious effect. As he had already said, the analysis Mr. Gray had so kindly given them was most interesting, but without time to carefully look into it, he hesitated to pass any opinion. In passing, he might remark he was surprised to note

in the analysis a percentage of copper. If they had copper under such conditions they would have corrosion, he also thought 12·32 per cent. of free oil was excessive.

Mr. GRAY said the quantities shown were the outcome of probably 20,000 gallons of water passing through the boilers.

Mr. FOTHERGILL said he was pleased to hear that remark, for he found that Mr. Gray after all appreciated his contention that there was a relation between the quantity of deposit and the quantity of feed-water supplied. It seemed almost unnecessary to say that no boiler, be it water-tube or Scotch, could give satisfaction if the water was loaded with deleterious matter which deposited in the boiler. It was not for him to say how such water became so loaded, or whether it was preventable or not. The oil question was one of great controversy. Different opinions and views were expressed. Some engineers entirely objected to the use of the lubricator, and believed, as Mr. Gray did, in the swabbing of rods. His own experience was to obtain the best cylinder lubricating oil —and there was oil and oil—and apply it by a lubricator, he was of the opinion swabbing rods meant the use of more lubricant, and generally an ordinary lubricating oil and tallow were used, although orders were given that tallow should not be used; but glands, as a rule, ran better by the use of a little tallow, and, if anything in the nature of india rubber packings were used, a high classed cylinder lubricant being a mineral oil, soon destroyed them. Judging from the analysis, considerable quantities of oil and fatty lubricant had been used; if not, how were they accounted for in the deposit? On various occasions he had ventured, both by papers and discussion, to support the water-tube boiler, and he still had the temerity to believe it had a future, and this more especially so since Mr. Gray had impressed them by his remarks that after all it was principally a question of manipulation, care and attention, to insure success. Messrs. Wilsons, of Hull, appeared to run the Babcock and Wilcox boiler successfully, although they failed to do so with the Belleville. There were water-tube boilers and water-tube boilers! and because one type of boiler in particular, viz., the Belleville, had completely failed, it did not necessarily follow that all were doomed, although the outcome of such failure undoubtedly produced a considerable amount of bias and prejudice detrimental to progress. The Boiler Committee appointed by the Government to investigate the whole question of water-tube boilers in the Navy certainly did not, in their interim report, condemn all water-tube

boilers. In fact, although they condemned the Belleville, they recommended other types for use. Of course it was not expected boilermakers who had extensive and expensive plant, thoroughly adapted to the making of the Scotch boilers, would support the water-tube boiler. He ventured to think the water-tube boiler offered facilities to complete combustion that could not be obtained where the ordinary furnace was used. When coal was thrown on the fire, and the hydro-carbon gases volatilised, it was imperative that the temperature of the gases so evolved should by no possibility be reduced, but increased, if complete combustion was to take place. Hydrogen effectively unites with oxygen at not less than 600 degs. Fahr., and carbon with oxygen at not less than 800 degs. The higher they exceeded these temperatures within certain limits the more readily they united, and the more complete combustion and efficiency. In the ordinary circular furnace of the Scotch boiler, working under a pressure say of 160 lbs., the temperature of the water inside the boiler was 363 degs., and the furnace crown plate about the same. As the hydro-carbon gases leave the fire a considerable portion come in contact with the crown of the furnaces, and if these gases have not already taken up their necessary quantity of oxygen to complete combustion, they will, due to the chilling effect of the crown plate, fail to do so unless their temperatures can be sufficiently increased, which in ordinary practice is impossible. In the water-tube boiler the capacity above the fire was large, and thus it was possible to devise what he might call a regenerative furnace by springing a brick arch over the fire and under the tubes, the effect would be that, when the fire was burnt down, the brick arch would, by radiation of heat from the fire, become exceedingly hot, and thus the early hydro-carbon gases after fresh firing would, by contact with the arch, be heated up sufficiently to readily combine with oxygen to complete combustion and prevention of smoke, soot and small ashes. This should remove much of the difficulty referred to by Mr. Heck, in which he pointed out the inefficiency due to blocking up between the tubes with soot and small particles of coke. He (Mr. Fothergill) admitted there might be practical difficulties to the fixing of such a brick arch, but he thought they were surmountable. He quite agreed with Mr. Heck and Mr. Gray that if the grate surface was excessive, particularly in length, say exceeding 5 feet 6 inches, it was a difficult matter to stoke properly; of course width could be overcome by increasing the number of doors, but their chief difficulty was want of good firemen who knew their work. He had seen a good man go into a stokehold and maintain steam with his jacket on, whereas another man,

bare to the buff, could do nothing. He felt sure if steamship owners fully realised the economy, not only in coal but in increased speed, a really good fireman meant, they would endeavour to evolve a practical scheme for training such men. Whilst they were straining every nerve to save in the machinery another fraction of a pound of coal per I.H.P., they practically ignored the very first element—the man who put the coal on the fire. Before sitting down, he wished to thank the author for his most excellent paper. He looked upon it as a most valuable contribution to the *Transactions* of the Institution. There were many features in the paper he should have liked to have referred to, but time did not admit. He trusted there would be a good and effective discussion.

The following communications were taken as read :—

19, James Street, Liverpool,
April 4th, 1901.

Edwin Griffith, Esq.

Dear Sir,—I am very much obliged to you for sending me a copy of your paper on Water-tube Boilers, it is most interesting, and I admire the care and research of the appendix.

The point I am much interested in at present is the presence of air in feed-water, and when there is superheating with *air* present, the corrosion is very much worse. We find with 80 lbs. steam, when there is a little superheating and no appliance for getting rid of the air is fitted, it corrodes stop chests, &c.

In triple engines, when Weir's heater is fitted with all fittings for clearing *water of air*, the life of our boiler tubes is about doubled. My experience of water-tube boilers is limited, but I believe that three-fourths of the trouble would disappear if the feed was heated after the manner of Weir's arrangement. Air and other gases are very quickly liberated from water under heat in a vacuum.

Management.—Your last sentence charmed me; the designer of boilers does not often think, as you put it, "on the past habits of the men in the stokehold." To my mind it is difficult to heat up the engines quickly as the boilers, and if as much care was taken to heat boilers quickly they would not suffer. Broadly, a boiler (tank) does not object to be heated quickly provided it is uniform. Now, I would suggest that say a *water-tube boiler* be kept and used for heating up circular boilers quickly. As far as I can understand, the Navy never use circulators, now we never get steam without circulating, often getting water up to 212 degs. from auxiliary boiler.

In a water-tube boiler we re-tubed lately, we found all scale inside the tubes first row next fire, beginning about one foot from the furnace door to four feet back (Blechynden type).

In appendix No. 35, page 176—

It will take a very short run before the "Marietta" boilers plus coal will overtop the "Wheeling" boilers and coal.

If both ships had to do two days run at consumption mentioned, and say 1000 I.H.P. weight, boiler and coal would be equal.

Again thanking you for the copy of your paper,

Yours faithfully,

AND. HAMILTON.

LONDON, *April* 23*rd*, 1901.

DEAR MR. DUCKITT,

I think Mr. Griffith is to be much congratulated for having dealt with the principal characteristics of the various types of water-tube boilers in such an impartial manner, and the Institution is under a double debt to him for having appended to his paper particulars of the literature dealing with the subject, which cannot fail to be of great service to the large and increasing number of engineers who are interested in water-tube boilers.

The basis suggested for comparing the relative economies of boilers seems to be a very satisfactory one, combining as it does the consideration of coal economy as well as the capacity of the boiler at that economy.

With regard to the remarks made about combustion space, there is no doubt that a satisfactory arrangement of furnace for large tube boilers has yet to be arrived at, as with existing designs should the fire become thin in any part, the excess of air passing through it lowers the temperature of the gases locally, and as the gases ascend almost vertically the tubes immediately above the thin place are subjected to a change of temperature which must produce local stresses in them and render them more liable to pitting, in addition to the prejudicial effect the excess of air must have on the economy of the boiler. In an ordinary marine boiler furnace the effect of a thin place in the fire, though bad, is minimised by the fact that when passing over the bridge the gases are mixed to a considerable extent, tending to promote more efficient combustion, and reducing the possibility of local strains being set up. In the Belleville boiler this defect is to some extent overcome by the use of jets of compressed air which mix the gases, but the fact that this

apparatus is necessary is not by any means a recommendation. The proper method of dealing with this matter would seem to be to so design the boiler as to ensure adequate mixing of the gases, without at the same time reducing their temperature too much, and to provide space for the complete combustion of the gases after this mixing has been effected.

I am in cordial agreement with the views expressed by the author on the question of circulation, and think that they shew the advantages which accrue from the use of boilers having high angle tubes. Ohm's law for electric circuits may be usefully employed to assist in crystallising one's ideas with reference to circulation in boilers. The law is usually expressed in symbols $C = \frac{E}{R}$; here C may be taken as representing circulation; E the force producing circulation, this force being proportional to the difference in specific gravity of the contents of the up and down corners; R represents the resistance to circulation, and clearly depends generally on the tortuousness or directness of the path traversed by the water. The lower the value of R the greater will be the circulation, and also the capacity of the boiler to withstand forcing.

In connection with this question of circulation, I think it may be of interest to consider the case of a boiler which is evaporating as much water per square foot of HS as experience with it has demonstrated to be safe, and to trace the probable effect on it of altering the angle, diameter or length of the tubes. I take it for granted that another way of describing this limiting condition of the boiler is to say that the proportion of steam to water in the heated tubes is as high as can be safely employed without risk of burning them, this, at any rate, seems to be a reasonable assumption. If now, without altering other conditions, the angle of the tubes to the horizontal be lessened, the velocity of circulation will be reduced, for, as is clearly shown in the paper the energy available for the production of circulation is reduced also. From this it follows that the proportion of steam to water will increase, and the boiler will not be as safe as before; in order to restore the former proportion of steam to water the evaporation per square foot of HS must be reduced, consequently the capacity of the boiler is reduced.

In a similar way the effect of reducing the diameter of the tubes, other things remaining as before, is to increase the proportion of steam to water; the heating surface decreasing in a less proportion than what may be termed the discharging capacity of the tubes. Increasing the diameter of the tubes from similar reasoning increases the safety of the boiler.

If the length of the tubes is increased, the evaporation per square foot of HS remaining the same as before, the limiting condition will be again passed, from which it appears that for a given evaporation per square foot of HS, and with a given type of boiler, there are limiting conditions affecting the angle, diameter, and length of the tubes, these three elements reacting on each other.

These considerations, if pushed to extremes, would result in boilers being made with tubes of varying sizes, the rows next the fire being the largest, the other rows diminishing in size as they recede from it to correspond with the smaller amount of heat absorbed by them. Although this would be carrying the matter too far, it is interesting to note that Messrs. Yarrow have for some time made the rows of tubes next the fire of larger diameter than the others.

I am strongly of opinion that the suggestion in the paper, to put retarders in the tubes nearest the fire, is not a good one, as they would have the same effect on the circulation as a reduction in the diameter of the tubes. The same remark applies to Serve tubes, but it is possible that both of these devices may be used with advantage in the tubes more remote from the fire, always provided that such tubes do not act as down comers.

With regard to the large question as to what is the proper sphere of usefulness of water-tube boilers in their present state of development, there is a wide divergence of opinion; but I would suggest that many cases exist where the advantages of such boilers, as summarised on page 158 of the paper, completely justify their use, and that as the defects of such boilers, which are frankly acknowledged, are removed, so their use will extend until they become the predominating type.

Yours faithfully,

R. DUMAS.

KING'S COLLEGE, LONDON, *April 24th*, 1901.

DEAR MR. DUCKITT,

Before remarking upon this paper I should wish to be allowed to record my sense of the extremely clear and practical nature of Mr. Griffith's treatment of this interesting subject, and if some of my remarks should appear critical I trust that Mr. Griffith will kindly understand that they are expressed purely with a desire to elicit correct information upon a subject which is not altogether free from obscurity. In my opinion one of the chief advantages of the water-tube boiler has not been directly expressed in Mr. Griffith's enumeration, that is that

with the types of water-tube boiler which I believe are the best, the maximum economy is coincident with the highest rates of steaming, an advantage which is not possessed by the fire-tube boiler as ordinarily designed. Mr. Griffith indirectly points to this fact when he states that "on his basis of comparison the water-tube boiler is superior to the fire-tube and may be said to be inherently more economical." This latter statement is very much open to question. What I understand Mr. Griffith to mean is that a water-tube boiler will produce more steam for a given weight of coal and a given weight of boiler than the fire-tube, and this is no doubt correct. It is more emphatically true if you take the weight of water into account as well as the weight of boiler, but of course this is accompanied, as Mr. Griffith mentions, by the disadvantage that feeding the boiler must be more carefully watched than with a fire-tube boiler, as the reserve of water in the boiler is very small. To say that the water-tube boiler is inherently more economical than the fire-tube requires a much wider basis of comparison than the above, because the economy of producing a large quantity of steam from a small quantity of coal for a given weight of boiler may be bought very dearly if repairs, cost of management, etc., are correspondingly great. These two items and other similar items must necessarily be included with the cost of coal in estimating the resultant inherent economy of the two boilers. I am sure Mr. Griffith realises this as much as I do, but I think that his paragraph on economy does not clearly express this meaning.

In deciding which is the best type of water-tube boiler the greatest difficulty of all is to free one's mind of prejudice, and especially of the prejudice produced by the long history and magnificent services of the fire-tube boiler. May I be allowed to say at once that I am not one of those who believe that either the fire-tube or the water-tube is inherently the best boiler. I believe that each has its wide range of application, and that the fact of believing in the water-tube boiler does not in any way mean that one does not believe also in the fire-tube boiler for its own particular sphere. With the fire-tube boiler it has been found that, in order to permit of frequent cleaning of the tubes, straight tubes are the best. This has also been emphasised by the fact that fire-tube boilers have not been generally used for very high pressures. Consequently expansion and contraction could be allowed for in the fire-tube boiler, and, except when the fire-tube boiler was forced to a rate of evaporation quite beyond its real capacity, no great trouble from leaky tubes was experienced. As soon as higher rates of evaporation were required to meet the demand for crowding the highest possible power

into the smallest possible space the fire-tube boiler was found unsuitable. In passing to a boiler which could meet these requirements more efficiently, my firm conviction is that we must entirely depart from the practices adopted with fire-tube boilers in so far as straight tubes and frequent cleaning of the tubes are concerned. At high rates of evaporation, high pressures, consequent high temperatures, and with the resultant large expansions and contractions, we must arrange for those expansions and contractions to be taken up easily and without damaging the construction of the boiler. Straight tubes are eminently unfitted for this purpose because we cannot make an expansion joint which will stand the strain without prohibitive cost. Then, to produce high rates of evaporation, we must have very rapid circulation, and this is directly induced by the reduction of the size of tubes; a secondary advantage being that with a small tube you necessarily, as Mr. Griffith points out, have a lighter tube for given strength. As the water is inside the tube instead of the flame, as in the fire-tube boiler, there is not of course the same tendency to foul that there is in the fire-tube, and what tendency there is has to be met in two ways: first, by purifying the water before entering the boiler; secondly, by making the interior of the tube as smooth and clean as possible and as little subject to chemical deposit as possible, so that the rapid circulation shall succeed in keeping the tube clean without mechanical cleansing. Where these two conditions cannot be met I am firmly convinced that a water-tube boiler can only be an imperfect instrument. Therefore I believe that to get the highest benefit from the characteristics of the water-tube boiler, a boiler with bent tubes and with small tubes is an essential. A water-tube boiler with large tubes and with straight tubes can only be a compromise, which may of course be better under particular conditions than the fire-tube boiler, and, where the requisite care cannot be ensured, may be better from ease of working and management than the small tube boiler; but you are avowedly using a compromise and therefore cannot expect the same results that you would with the small tube boiler.

With regard to Mr. Griffith's remarks upon draught, I do not agree with him that it is a necessary waste to send heat up the funnel beyond recovery. There are only two ways of producing a draught, either directly by difference of temperature between the inside and outside of the funnel, or, secondly, by mechanical means. The temperature inside the funnel must of course be above the temperature of the steam or else your heating surface is of no avail. It must be considerably above the temperature of the steam or the heat gradient through the plates will be so small that

the gases must pass at an extremely slow rate in order to part with their heat at all, and therefore an altogether impracticable size of fire grate would be required for a given quantity of steam. Therefore, even if mechanical draught were entirely resorted to the temperature of the gases must be 400 or 500 degs. Fahr. at least. Therefore it is not merely for the sake of producing the draught that heat is sent up the chimney; it is so that you should get any steam at all. But of course I entirely agree with Mr. Griffith that, after this heat has passed the heating surface, if it can be utilized more efficiently than for producing draught, it would be beneficial to so use it. It is not, however, very easy to obtain a more efficient use for it than that of draught producing. With regard to "drowned" tubes *versus* "undrowned" tubes, I think Mr. Griffith is wrong in stating that the controversy has been settled in favour of "drowned" tubes. In my opinion it has both practically and theoretically been proved that the "undrowned" tubes are the best. The "drowned" tubes are more frequently used than the "undrowned" tubes, partly from prejudice, partly from a desire to avoid infringing patents; but I unhesitatingly believe that the "undrowned" tube is the correct form of tube both from a practical and a theoretical point of view. I must close these somewhat lengthy remarks by again very cordially thanking Mr. Griffith for his interesting and valuable contribution to the literature on water-tube boilers.

Yours faithfully.

D. S. CAPPER.

HIGH BRIDGE WORKS,
NEWCASTLE-UPON-TYNE,
March 28th, 1901.

DEAR MR. GRIFFITH,

I have just read the proof of your paper on "Water-Tube Boilers," and I thought it might interest you to see what nickle steel 25 per cent. may be like after working in and exposed to sea water.

I enclose a photograph (Plate XIX.) which speaks for itself. It is of a $2\frac{1}{2}$ inches diameter pump rod from a sanitary pump in a mail boat, and had only been at work under ordinary conditions for about five months doing duty as sanitary and deck pump working with salt water.

Further, as to the behaviour of boiler tubes and baffles in water-tube boilers, I have received a private report from a friend with reference to the boiler installations of a fast cruiser, fitted with eight Blechynden Express water-tube boilers carrying 300 lbs. pressure, and developing over 7,000 I.H.P. He writes:—

I saw some of the baffle plates out, and they are as good as when first put in. In the vessel's stay at home this time, she went through an examination test; that is, so many tubes to be drawn out of two or more boilers. The boilers Nos. 1 and 5 were selected. A cross row was taken out in No. 1 on one side only. In No. 5, two rows were taken out, one on each side. I saw these tubes myself, and they were as good as when first put in, and a sin to disturb them. A and B rows, next to the furnace, were grand. C rows only showed very slight signs of pitting. To wind up, the ship has been put in the list as perfect for another three years.

I enclose drawing of the boiler with the tube rows and baffle plates referred to marked. (See Plate XX.) The numbers 1 and 5 are the reference numbers of the boilers, there being eight in the ship.

Yours faithfully,

T. C BILLETOP

A SIMPLE METHOD FOR PREVENTING THE CORROSION OF TAIL SHAFTS.

By JAMES M. THORNTON.

[Read before the Institution in Sunderland on April 26th, 1901.]

As the failure of tail shafts was fully discussed by many of the members of the Institution about two years ago, it is not the intention of the writer to remark upon any of the points then raised.

The object of this short paper is simply to put before the members the result of some years' experience on the protection of tail shafts from corrosion, and to prove that tail shafts can be preserved and made to last for years without breaking.

The sectional drawing (Plate XXI.) will shew the method which the writer has adopted for some years with special satisfaction.

A is a small deck cap and flange on cabin floor, to which is connected an inch galvanized pipe C leading through after peak tank top B and screwed into stern tube at D. The pipe C should be securely stayed in the after peak, and a flange with a conical hole in should be bolted on the tank top at B with a little packing, so as to form a simple gland and allow for vibration of pipe when in heavy weather. At any convenient place between the tank top and cabin floor, the pipe should be an inch open and coupled up with a short piece of indiarubber tube so as to allow the deck to vibrate without the danger of breaking the pipe. The stern tube is then filled through the pipe C, with a mixture of common oil, tallow, and white lead, all boiled together and put in hot. Care should be taken not to put too much tallow into the mixture or it will "set" in the tube and simply form a shell of tallow (fast to tube) in which the shaft will revolve. When mixing this, a ladleful should be taken out of the kettle or pot in which it is boiled and immersed in cold water, so as to get it of the right substance when in cold water. It should be of the same substance as soft soap (when in cold water) so that it will run freely into the whole empty space in the stern tube, and into grooves between lignum vitae. Whilst pouring the mixture into the tube, a little

cold tallow should be plastered around the liner at outer end of stern tube to prevent leakage until ship is afloat, taking care to leave a small air vent hole at the upper side. The screwed cap should then be put into the deck flange. The stern gland should be screwed up tight, so that when the engines are working no oil mixture or water will pass through. It is practically impossible to screw this gland up dangerously tight, as if this is done to such an extent as to heat the gland and shaft, the result is only to melt some of the mixture which will "ooze" through and keep the parts from "seizing." In such a case the gland should be slacked back a little, and when once adjusted it will run for months without alteration, and without allowing any water to pass through. It is obvious that, so long as nothing passes through the stern gland, the water pressure on the outside tends to force and keep the oil mixture in the stern tube, and the cap on the pipe at the deck being fitted air tight leaves a certain amount of space in the pipe which tends to prevent the mixture leaving the lower part of the pipe.

After the stern tube is once thoroughly filled in drydock, it has been the practice of the writer to put about half a gallon of cheap oil and a little white lead down the pipe, say, about once every month or six weeks when the vessel is afloat.

The next point the writer would briefly remark upon is the outer end of the after liner. It is agreed that all brass liners should enter a recess in the propeller boss, and the space between the liner end and bottom of the recess filled with suitable jointing material. If this work is done very carefully it generally preserves the shaft there, but the result of the experience of the writer is that "when the work is done at night time (which is frequently the case), unless the person specially interested in the life of the shaft is there to see it fitted properly, and the space in recess properly jointed, so as to be water tight," there is a chance of water getting into the recess, which of course results in the corrosion of the shaft. To thoroughly ensure getting this part kept free from water, the writer has fitted a conical brass flange (shewn at E on drawing). This flange is bored out conical, so as to thoroughly compress the marline lapping at F. The flange is securely bolted to the propeller boss and jointed with red lead. Brass bolts are fitted and the flange made in halves, so that it can be removed when the propeller is required to be taken off. Where ordinary care is exercised, the writer has never known this system to fail preserving tail shafts for years, and friends of his can also testify to its merits in keeping new tail shafts as bright as silver (all over), after having been in the tube over three or four years. The writer has at

present several steamers (large and small) to superintend, and *it is a fact* that the tail shafts when drawn for examination are in exactly the same condition as when last seen, and in some cases where new shafts were fitted a few years ago, they are practically as bright to-day as when they left the lathe. This method ensures the lignum vitae bearing lasting much longer, as some of the vessels so fitted have only worn down $\frac{3}{16}$ inch in three and four years, which shews the lubricating of shaft to be an advantage. The importance of this is obvious, as the bending strain (in addition to torsion strain) must become more and more severe as the shaft wears down, and if the slightest corrosion exists at the end of one of the liners the shaft is very unsafe. The experience of the writer includes supervision of vessels fitted with tail shafts having no brass liners, and simply running on cast iron bushes, and also of short stern tubes and one continuous liner on the shaft, but the object of this short paper is to place before the members the result of some years' working of the foregoing simple method of preserving tail shafts from corrosion, and breakage, where shafts are fitted with two ordinary brass liners.

DISCUSSION.

Mr. D. ANDREW, in opening the discussion, said Mr. Thornton's paper was, he hoped, the pioneer of what might be followed occasionally by other superintendent engineers with advantage to the Institution by giving, in the same concise form, the result of their experience on various subjects in connection with the management of the steamers and machinery under their control, and which could not fail to open up a wide field for discussion of an interesting and practical nature, not only of great advantage to those gentlemen, but also instructive to the members generally; for undoubtedly many hard facts came under their notice in the management of machinery and boilers at sea, which would be interesting and instructive to those members who had no direct practical experience with the subject. The subject of Mr. Thornton's paper had been before this Institution in various forms, but when first introduced, means were not then generally adopted to prevent the corrosion of tail shafts, now admitted to be the primary cause of their failure and short life, which became shorter after the introduction of steel as a material for propeller shafts. The frequent breakage of shafts, shown in a list issued some few years ago, raised an interest in the subject and resulted in the shafts being increased in size in many instances, also Lloyd's annual survey of what may be called aged shafts,

which had undoubtedly reduced the number of broken shafts; but this in his opinion was not due to the shafts being made larger in diameter, but the result of shafts being more generally protected, and frequent examination; for when there was an incision found, caused by galvanic action, the depths of which could not be ascertained, it condemned the shaft. This course had certainly minimized the number of broken shafts, but it was undoubtedly a drastic and uneconomical method of dealing with them. If such means as Mr. Thornton described were more generally adopted to prevent corrosion of shafts fitted with the ordinary two brass liners (and many superintendents had adopted similar means), the lifetime of shafts would be considerably lengthened, the deadly corrosion prevented, and they would practically remain as bright as when they left the lathe, with the advantage of lubricating the stern bush, minimizing the wear, and what had been proved conclusively, increasing the revolutions. Some years ago he examined the shaft of a Norwegian steamer, which was run in fish oil, passed into the tube in a similar manner to that described in the paper, and it showed splendid results, the oil having formed a thick skin adhering to the shaft, and which was pared off with a knife. He would have been pleased if Mr. Thornton had favoured them with the age of the shafts protected in the manner he described, also, the material of which they were made, as this would be some guide to what in safety should constitute the life of a propeller shaft; for it must be admitted, that, considering the continual torsion and bending strain to which a shaft is subjected, particularly through the racing of the engines, there must be a limit of life even with the best protected shafts, and this safe limit with the different materials used in their construction was what they wanted to arrive at. This could only be obtained from actual practice and observation of those in close touch with the subject. He congratulated Mr. Thornton on having again brought forward a subject of such vital importance, but a subject which he had no doubt was coming to be regarded as threadbare, still, with all the thrashing it had undergone, the questions to be answered still stood prominently forward, viz.: "What are the best means to adopt to protect propeller shafts, and what should be their safe limit of life?"

Mr. J. R. FOTHERGILL (Vice-President) said that it gave him pleasure to speak in corroboration of the statements made by Mr. Thornton in his paper. Over two years ago he (Mr. Fothergill) fitted in two steamers a design of piston lubricator in which they used a hydraulic cup leather

piston, this piston was fitted into a copper pipe about 18 inches long and 3½ inches diameter. The piston rod was screwed its whole length and passed through a screwed hole in the boss of a wheel. The lubricator was fastened to the bulkhead at the end of the tunnel and had a pipe leading through the bulkhead into the stern tube. The piston was screwed out of the pipe and the pipe filled with vaseline and the piston then screwed into its place. After the stern-tube became filled with grease they found the screwing down of the piston in the pipe about an inch every two or three days was quite sufficient to keep the stern tube fully loaded. He preferred a solid lubricant to oil as it did not readily escape from the after end of the tube and required no special arrangement to keep it in. In one boat the shaft was somewhat corroded when the lubricator was fitted and under ordinary conditions would certainly have been condemned some time since; but under the present arrangement there was no evidence of any extension of the usual corrosion and cracking and the life of the shaft seemed good for a long time yet. In the other case the lubricator was fitted at the same time as a new shaft and he could only say the shaft was in as good a condition as the day it was fitted. He might also say the wear of the stern bush during the two years had certainly not exceeded $\frac{1}{16}$ of an inch. He congratulated the author on his paper.

The discussion was adjourned and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SEVENTEENTH SESSION, 1900-1901.

PROCEEDINGS.

CLOSING BUSINESS MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, MAY 17TH, 1901.

J. R. FOTHERGILL, ESQ., VICE-PRESIDENT, IN THE CHAIR.

The VICE-PRESIDENT said he was sorry the President was not able to be with them that night. He was on the Continent with Mrs. Withy for a rest and he was sure they all hoped to see him return in his usual vigorous health.

The SECRETARY read the minutes of the last General Meeting, held in Sunderland, on April 26th, 1901, which were approved by the members present, and signed by the Vice-President.

The ballot for new members having been taken, the Vice-President appointed Mr. John H. Heck and Mr. G. A. D. Toyne to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Atkinson, Alfred, Engineer, 17, The Exchange, Middlesbrough-on-Tees.

Green, John W., Rolling Mills Manager, 3, Shaftesbury Place, Gateshead-on-Tyne.

Hammersley, Benjamin J., Engineer, 47, Kingsley Terrace, Newcastle-upon-Tyne.

Johnstone, Joseph, Engineer, 7, Dean Street, Newcastle-upon-Tyne.

Murray, Charles W., Engineer, c/o Messrs. Babcock & Wilcox, Ltd., Ogle House, Farringdon Street, London, E.C.

Stupersky, Antony, Engineer Draughtsman, 37, George Street, Willington Quay-on-Tyne.

GRADUATES TO MEMBERS.

London, William Jas. Albert, Electrical Engineer, c/o Messrs. Brown, Boveri, & Co., Ltd., Baden, Switzerland.

Scott, George, Engineer Draughtsman, 36, Bede Burn Road, Jarrow-on-Tyne.

Varty, Bartholomew Snowball, Ship Draughtsman, Classensgade, 36, Stuen Poterbro, Copenhagen.

ASSOCIATES.

Hollis, John, Steel Agent, 29, Alexandra Place, Newcastle-upon-Tyne.

Pringle, George Frederick, Engineer's Factor, 29, Grainger Street West, Newcastle-upon-Tyne.

Roger, Thomas, Accountant, c/o Messrs. Sir C. Furness, Withy & Co., Shipbuilders, West Hartlepool.

Young, John Andrew, Rope Manufacturer, St. Ann's Rope Works, Newcastle-upon-Tyne.

PRESENTATION OF GOLD MEDAL.

The VICE-PRESIDENT said the next business on the agenda was the presentation of the engineering gold medal for the last session. After very careful consideration the Council had decided to give the gold medal to Professor R. L. Weighton for his paper on "The Receiver Drop in Multiple Expansion Engines." Professor Weighton had written expressing his regret at not being able to attend the meeting that night, he having to attend the College classes. He thought they would all agree that the paper which Professor Weighton had given to the Institution was a most valuable one, one in which the whole engineering profession not only of this country but in other countries must be deeply interested. It gave them figures and facts derived from actual results obtained under conditions exceptionable. The College engine was no mere toy, he believed it was larger and more suitable for its purpose than any other experimental engine in the world, hence the value of the paper, and he hoped the Professor would be able to supplement this paper by others in the near future. It was most unfortunate at this the closing meeting of the session that their President could not be present to present the medal, but he hoped Professor Weighton would accept it the same as if handed to him by the President.

The discussion on Mr. E. Griffith's paper on "Water-Tube Boilers" was resumed and closed.

The discussion on Mr. J. M. Thornton's paper on "A Simple Method for Preventing the Corrosion of Tail Shafts" was resumed and closed.

Closing business of the session.

MR. WALTER SCOTT'S REPLY TO THE DISCUSSION ON HIS PAPER ON "THE COMMERCIAL ORGANISATION OF SHIPYARDS."

The SECRETARY intimated that Mr. Walter Scott was unable to attend, and that he had not as yet forwarded any reply to the discussion on his paper. The reply when received would be published in the *Transactions*.

On the motion of the VICE-PRESIDENT a vote of thanks was accorded by acclamation to Mr. Walter Scott for his paper.

AYR, *June 26th*, 1901.

DEAR MR. DUCKITT,

I regret to say absence from home, abroad, has prevented me from replying sooner.

It was most interesting and also instructive to note the various points in my paper which appealed to the different speakers. It was not my intention when preparing the paper to lay down any hard or fast rules, the object was rather to deal with general principles in such a way as to bring the whole subject comprehensively before the minds of the members; and of course, various modifications would require to be made to suit individual establishments. I am glad to note that the use of statistical curves is coming into more general use; it must not be thought, however, that every kind of data can be plotted in this form, the difficulty is often to get a suitable unit of relative value for a basis, and one that varies in proper proportion; this is a point which requires careful consideration. In reply to Mr. A. M'Glashan, there is no doubt that too much centralisation must be avoided, and a large business must of necessity be controlled by several heads, the main point in this case is to see that the different departments dovetail properly into one another. It is a good plan for the different controlling members to meet altogether once a day for general discussion of different matters. I referred to staff, foremen, etc., as "non-producers" rather in the sense that their productions did not show directly, and that their salaries could not with certainty be charged to any particular job, although in the case of draughtsmen and under foremen this could be, and was

sometimes done. I am of opinion that the weekly wages sheet handed to each foreman, as mentioned by Mr. R. W. Vick, is a most valuable suggestion, and calculated to do useful work. In reference to the query relative to the treatment of invoices by the same speaker; it is a good plan in a large establishment to docket them—after being checked—in say book shape boxes with spring clips, such as Stone's world file, reserving one or more of these for each letter of the alphabet. When the invoice is put in the file it is given a consecutive number, and on the lid side of the file a sheet of white paper is gummed, so that if at any time an invoice requires to be taken out for reference, the particular clerk doing this can make a pencil note of the invoice number and append his initials thereafter. This is scored through when the invoice is returned—of course, the files should be kept under the sole control of the clerk who is responsible for them. At the end of the year or oftener they can be filed in a simple and permanent manner, together with an abstract. The advantages are easy and quick filing, and easy access for hurried reference, also easy subdivision of labour when abstracts or other information is desired to be got out for any particular class of goods or any particular ship, or for work in connection with periodic balancing. Invoices should never be allowed out of the office after once having been checked, and even for checking should always be in the charge of say a junior clerk or similar person who is responsible for their custody, and who can, if necessary, assist the storekeeper in the checking off of the different goods invoiced.

In conclusion, I desire to thank those members who have so kindly taken part in the discussion of a subject which was probably by no means a novel one to them.

Yours faithfully,

WALTER SCOTT.

RESUMED DISCUSSION ON MR. E. GRIFFITH'S PAPER ON "WATER-TUBE BOILERS."

MR. A. ATKINSON (of Messrs. Babcock & Wilcox, Limited) said his firm had given a great deal of time and consideration to the making of water-tube boilers for the Navy and also for the Mercantile Marine and other purposes. He had expected their superintendent of the marine department to have been present. There was one point he rather differed from Mr. Heck in his remarks at the last meeting. He referred to inefficient combustion owing to the flame being amongst the tubes. They found that they could evaporate the same quantity of water, probably more than with the ordinary Scotch boiler heating surface, and that being so he could hardly see how it followed that the evaporation was not so efficient in water-tube boilers as in any other type. Mr. Griffith's paper had been very interesting reading to him. Perhaps he might give them some results received from H.M.S. "Sheldrake." They had had this vessel fitted with their boilers and put to very severe trials. They had four one thousand mile runs at 1,500 I.H.P.; two one thousand miles at 1,800 I.H.P.; two one thousand miles at 2,000 I.H.P., and one thousand miles at 2,150 I.H.P., besides trials at 2,500 and 3,000 I.H.P., all highly satisfactory to the Government. Probably the United States led in this direction as in many others. Commodore Melville of U. S. Government made special reference to the performances of the "Annapolis" and "Marietta" gunboats. Both of which had appeared in the *Engineers' Gazette* (Vol. XII., p. 230). Before the outbreak of the war the "Annapolis" was employed to prevent filibustering, and the "Marietta" had been engaged in ordinary cruising in the Pacific. The "Marietta" made a trip almost as long as that of the "Oregon," leaving San José de Guatemala on March 16th and arriving at Key West on June 4th, having been under steam continuously for nearly three months, and having covered a distance of over 13,000 miles at an average speed of 9·2 knots. Mr. Melville says: "The special points to be noted in connection with both vessels is that after more than a year's commission, during which time they have steamed thousands of miles, the boilers of both vessels are in excellent condition and ready for service—they have withstood the test of long periods of actual cruising just as well as cylindrical boilers, and with as few

mishaps as any and much fewer than some. In the case of the 'Marietta' all that was called for at the end of her long trip were a few fire-bricks, and the 'Annapolis' needed nothing." He ventured to believe the day of water-tube boilers was coming, and he thought Messrs. Babcock & Wilcox would have a good look in.

MR. E. GRIFFITH'S REPLY.

Mr. EDWIN GRIFFITH, replying to the discussion, said in the first place he would like to thank all those gentlemen who had taken part in the discussion on his paper, and he wished to congratulate the Institution on the high value of the discussion. He only intended to deal with such matters as had a direct bearing upon the paper, and he would take each section of the paper in turn with its own portion of the discussion for his remarks.

Beginning with the "Introduction," Mr. W. R. Cummins did not quite agree with his use of the terms "express" and "large tube" boilers. He did not want to impose them upon anybody except for the purposes of the paper. It would be impossible to use any general term which would include every water-tube boiler made or proposed. Passing on to the next section, "Fire-Tube and Water-Tube Boilers Compared," he wished to start the paper by giving a statement of what he thought to be a fairly general opinion among those who had studied the matter. Some of the points were quite open to question he knew, and further experience was necessary before they could pass a final judgment upon them. It would have taken a volume to have brought in all that could be said for and against every point in this section, so he did not attempt it; but there was one feature Professor Capper claimed as an additional merit for the water-tube boilers beyond what he (Mr. Griffith) gave in the paper. He remarked:—"In my opinion one of the chief advantages of the water-tube boiler has not been directly expressed in Mr. Griffith's enumeration, that is that with the types of water-tube boilers which I believe are the best, the maximum economy is coincident with the highest rates of steaming, an advantage which is not possessed by the fire-tube boiler as ordinarily designed." If he (Mr. Griffith) understood that statement rightly, he did not agree with it. He did not know any water tube where the highest economy was coincident with the highest evaporation. The fact was that the furnaces were too small to obtain that result. Coming to the section on economy he referred to Mr. Heck's idea as to the wire gauze action of the tubes. Such action might possibly occur when the tubes

were too closely pitched; but he thought in actual water-tube boilers this did not happen. He thought the back tube-plate of the ordinary boiler more like wire gauze than anything that existed in the fire space of a water-tube boiler. This point was very important because he gathered from Mr. Heck's remark that in his opinion it was impossible to have proper combustion in the water-tube boiler. If that were so they might abandon it altogether as far as merchant vessels were concerned. They could never use water-tube boilers extensively in ordinary merchant ships unless they could give economy. He could not, however, agree with Mr. Heck's view, and, as Mr. Atkinson had pointed out, under favourable test conditions very high results were obtained in water-tube boilers. With reference to Mr. Fothergill's remarks as to what took place in the ordinary boiler when the flames were cooled by the furnace crown, he could not quite follow his meaning on that point. The thing was important because it bears on what they ought to aim at in designing the furnaces of water-tube boilers. In the report of Mr. Fothergill's remarks he found:—"In the ordinary circular furnace of the Scotch boiler, working under a pressure say of 160 lbs., the temperature of the water inside the boiler was 363 degs., and the furnace crown plate about the same. As the hydro-carbon gases leave the fire a considerable portion came in contact with the crown of the furnaces, and if these gases have not already taken up their necessary quantity of oxygen to complete combustion, they would, due to the chilling effect of the crown plate, fail to do so unless their temperatures could be sufficiently increased, which in ordinary practice was impossible." It seemed to him (Mr. Griffith) that what took place in the ordinary boiler was this: the gases after they had been cooled by the furnace crown passed over the bridge and got mixed up with the other gases that had not been cooled, and if the combustion space was adequate and suitable then the temperature might under favourable conditions be raised sufficiently for complete combustion. That he took to be the great advantage of the furnace arrangement and the combustion space in the ordinary boilers, and he did not quite see why a somewhat similar arrangement could not be followed in the water-tube boiler as well. There had been such a great desire for getting as much heating surface and boiler power into as little space as possible that it had led to the neglect of a proper arrangement of furnace space. He quite agreed with what had been said with regard to small furnace units, and he did not think each furnace should be very much larger than in an ordinary boiler. On the question of combustion spaces, he agreed with Mr. Dumas'

remarks, which were summarised in this paragraph :—"The proper method of dealing with this matter would seem to be to so design the boiler as to ensure adequate mixing of the gases, without at the same time reducing their temperature too much, and to provide space for the complete combustion of the gases after this mixing has been effected." And then, of course, the gases should be allowed to pass among the tubes. He (Mr. Griffith) contended there was nothing inherently impossible about that if the necessity was recognised. Coming to Mr. Cummins' remarks on the suggestion of comparing economies of different boilers, he objected to his proposal on that point in the following sentence :—"Passing on to the question of economy, I think Mr. Griffith's suggestion of basing the comparison on weight of boiler would be most unfair to the ordinary boiler. The weight economy should be kept distinct from the thermal economy, otherwise a badly-designed but light water-tube boiler would be rated above a well-designed ordinary boiler. I think a better suggestion would be to specify a certain consumption per square foot of heating surface, and the best boiler would evaporate the most water per lb. of combustible. The weight economy should be treated separately." That weight economy should be treated separately was what he (Mr. Griffith) suggested. Good economy should be first insisted upon, and then, having secured that, the weights of the different boilers under comparison should be considered, and that which was the lightest for the same work he would regard inherently better in the matter of capacity, and that was what they wanted in many ships. In this comparison, Prof. Capper suggested that cost of repairs, etc., should be included. If they could get a formula to include everything all the better, but he (Mr. Griffith) thought it more convenient to consider each point by itself, and then judge the general result. Mr. Foster asked if he included weight of water in that comparison? Yes, he meant the steaming condition. He quite agreed with Prof. Capper's remarks *re* the funnel heat and was glad he had referred to it, as his own brief reference in the paper might be misleading.

Referring to "Circulation," Mr. Dowsen asked him what he considered the suitable size of tubes in large-tube boilers? It was very difficult to say, because it depended a good deal upon the conditions, but a broad rule was that horizontal tubes should be comparatively large, and steep tubes small. It depended on the length and on the circulation; for instance, in a boiler like the Babcock, he thought that if the lower rows were made 4 inches and the others 3 inches, they would probably be suitable.

Mr. ATKINSON—May I be allowed to say that we have discarded altogether small tubes and adopted as the marine standard 3¼ inch tubes.

Mr. GRIFFITH thought they would probably get better results if they made the two bottom rows 4 inch tubes. Messrs. Babcock did try small tubes (1¼ inch or 1½ inch he thought), but such small tubes were entirely unsuitable for such a boiler as theirs. On the other hand, when they came to a vertical-tube boiler, such as Mr. Cummins had sent to this discussion, large tubes would not be so suitable. It was not so bad, however, to make vertical tubes large as making horizontal tubes too small. Mr. Cummins' boiler would be better to have 1½ inch or 1¼ inch tubes, unless for those adjacent to the fire. It would tend to keep them cleaner, they would be thinner, and he could get more of them into the same space or reduce the size of boiler. With reference to the size of tubes, Mr. Carnt, for Messrs. J. S. White & Co., wrote :—"We are inclined to doubt if the present tendency towards fitting larger diameter tubes next the fire in 'Express' type boilers should be followed without grave consideration. It is extremely probable that advantages would accrue from putting, say 1¼ inch tubes next the fire, where the bulk of the tubes as well as those next the fire had originally only been, say 1 inch diameter, but probably better results still would be obtained (I mean as regards endurance under *all* conditions of Naval Service) if *all* the tubes had been made 1¼ inch. If the tubes next the fire are large enough and *only just large enough* to stand the maximum condition of steaming they will be much more likely to give ultimate satisfaction than rows of tubes which do the *maximum* steaming very easily." He (Mr. Griffith) quite agreed with those remarks as far as they went, but if the tubes next the fire were only just large enough for the maximum rate, the others if of the same size would be larger than necessary for the maximum rate. He concurred with Mr. Dumas on this point.

Coming to the question of "Tubes," he referred to Mr. Billetop's communication showing a nickel-steel rod, which indicated that high nickel-steel was not always so non-corrosive as it was sometimes said to be. It was interesting to note Messrs. J. S. White's experience with retarders in tubes. He (Mr. Griffith) had mentioned the possibility of retarders being an advantage with a view to eliciting opinions upon the point. Personally, he very much doubted whether retarders should be used in water-tube boilers. He did not think they should

in Navy boilers, because the average rate at which they worked was too low, as pointed out by Mr. Carnt. On the other hand, if water-tube boilers with steep tubes came to be used in channel steamers, he thought it might be an advantage to have retarders under such conditions. Professor Capper did not agree with his remarks upon undrowned tubes. He says: "With regard to 'drowned' tubes *versus* 'undrowned' tubes, I think Mr. Griffith is wrong in stating that the controversy has been settled in favour of 'drowned' tubes. In my opinion it has both practically and theoretically been proved that the 'undrowned' tubes are the best. The 'drowned' tubes are more frequently used than the 'undrowned' tubes partly from prejudice, partly from a desire to avoid infringing patents; but I unhesitatingly believe that the 'undrowned' tube is the correct form of tube both from a practical and a theoretical point of view." He (Mr. Griffith) was not prepared to admit that the present preference for "undrowned" tubes was due to prejudice. At the time the Admiralty adopted "Express" boilers for torpedo-boat destroyers of 27 knots, they had tried a number of promising designs, and were willing to give several kinds of boilers a a trial. At that time there was no special objection made by the Admiralty to "undrowned" tubes, and they were quite as ready to accept them as the others; but now, after several years' experience, they certainly have a preference for "drowned" tubes, and he thought that that was the result of experience and not bias. There had been very little discussion with regard to the manufacture of tubes, though he thought it one of the most important points in water-tube boilers. Mr. Cadman, of the Harrison Line, in a letter to him, remarked, that "the life of ordinary boilers depended upon accessibility, and to seeing that the heating surface was as clean as possible. No doubt the water-tube boiler of the future will also be easily cleaned, and when the tube-makers get over their troubles, the boilermakers will have to take a back seat."

Coming to the section on "Endurance," he thought Mr. Gray's experiences were very interesting, and he hoped the mud trap he described would prove as successful as he anticipated. He gathered that as yet his experience was not sufficiently lengthy to pass a final judgment upon it; but he appeared to have found a decided advantage from its use so far. He (Mr. Griffith) thought a better plan might be if the trap were entirely outside the steam drum but connected with it, so that anything overflowing from the mud trap would not so readily go amongst the tubes. With such a boiler as Mr. Gray referred to everything they could do in that direction was necessary. He did

not think that boilers with horizontal tubes would ever do well unless they could have clean water. Mr. Cummins thought he (Mr. Griffith) did not sufficiently emphasise the importance of keeping the outside of the tubes clean. He recognised its importance and referred to it as a vital matter in the paper, but he was glad of further attention being drawn to it.

The sections regarding "Construction" and "Cost" excited practically no discussion, and the same remark applied to "The Management of Boilers." There was one thing regarding the management of water-tube boilers which, he thought, might be noted. He did not consider it was fair to expect a water-tube boiler to stand exactly the same treatment as an ordinary boiler, as some variation might be required; at the same time the attention necessary must be such as could be given by the kind of men available in the stokehold.

Regarding the "Conclusion" of the paper, the main point was, he thought naval engineers would be compelled to persevere with water-tube boilers, and he thought there was a general disposition to agree with that since the Boiler Committee had reported, although he knew there was a strong opinion against that view also. The finding of the Boiler Committee—

The VICE-PRESIDENT—It is only an interim report—not a complete report.

Mr. GRIFFITH—Well, the report as far as it went was the view of a group of able engineers who could not be supposed to have been biased, and who had been engaged investigating water-tube boilers, many of which had proved troublesome. Under all the conditions of the case that they should come to that finding even provisionally tended to go a long way in support of his view. There was another fact in the same direction, and that was the conduct of the American Navy in this matter. Their attitude towards the water-tube boiler was quite a tentative one until the Spanish-American War. They certainly made no rush at it; but were very cautious with the whole subject. The water-tube boiler up to that time was tried in several forms, from about the year 1890, but they did not adopt it as the approved type up to the time of the Spanish-American War. The result of their experience in that war was that they had decided to adopt the water-tube boiler, although in doubt as to a suitable type. With regard to the merchant service he thought the experience gained by naval vessels would be of considerable use, and in

the meantime they should wait the result
justified so far in putting any water-tube
vessels. He did not think they were
to justify the change in such ships, unless
power channel steamers the time seemed
should not be used. Anyone contemplating
with ordinary boilers should consider
classed on the same route by water
express type. This was all he had
thank them for their very patient

The VICE-PRESIDENT said the
reply to the discussion on his
references to the interim report
Admiralty to examine into the
purposes, if he (the Vice-President
Committee expressed the opinion
skill are required on the part
stood this aright it meant an
vessel, instead of leaving such
and was a most strong
Morison's paper, "The
Navy, the Spanish war
water-tube boiler, although
such boilers were not
largely due to the
with the Belleville,
boilers of the Babcock
the feeling of the
Griffith for his

This was

RESUMED DISCUSSION ON MR. J. M. THORNTON'S PAPER ON "A SIMPLE METHOD FOR PREVENTING THE CORROSION OF TAIL SHAFTS."

The following communications were taken as read :—

Mr. J. M. Thornton, London, *May 2nd*, 1901.

Dear Sir,

In reply to your favour of yesterday's date, I am pleased to say that your recommendation for the preservation of tail shafts has proved most successful, and I am fully satisfied that if the result is otherwise it will be clearly attributable to neglect and want of regular attention by those in charge.

In May, 1897, a new tail shaft was fitted to our s.s. "Nith," a pipe was fitted to the stern-tube, and the tube filled with hot tallow and oil. When inspected in July, 1899, the shaft was found in as perfect condition as when it left the lathe. It was again seen last March in the same condition, practically none the worse and showing no signs of fatigue, and no perceptible wear on the liners. The water has not penetrated more than about twelve or fourteen inches into the sternbush ; this is clearly defined by the tallow mark on the lignum vitæ. I may mention that the sternbush had not been re-wooded since November, 1895. It was re-wooded last March at the No. 3 survey. I have no doubt, if it had not been that the engines were very much used for four days getting the vessel off the ground at Mobile, it would, with the lubrication of tallow and oil, have been some years before it required new wood.

Yours faithfully,

Geo. Picot.

P.S.—The previous tail shaft was fitted in November, 1895, and condemned in May, 1897.

Eton Villa, Cathcart,
Glasgow, *May 9th*, 1901.

Dear Mr. Duckitt.

Mr. Thornton's paper on "A Simple Method for Preventing Corrosion of Tail Shafts," read at the last meeting of the Institution, calls attention to what is probably the simplest method of preserving tail shafts which

could be devised, and according to his testimony it is as effective as it is simple. There are at least three different methods of applying the system, which, I believe, are in use; although neither of them appear to be so well known as they ought, viz:—(1) The method described and illustrated by Mr. Thornton; (2) generally similar but having the inlet pipe carried through the bulkhead immediately above the stern-tube gland; and (3) with the pipe coupled to the bottom of the stern-tube, led through the bulkhead to a simple form of pump and having a small air cock on the top above the gland. The pump, as I have fitted it, consisted of a plain cylinder with a plunger which was forced down by a screw and handwheel, no valves being fitted. It was placed in the tunnel beside the stern-tube gland, and although I have not had the same facilities for watching the result of its application which Mr. Thornton has had, it has been reported to me more than once as having given great satisfaction.

With regard to the packing at the propeller boss, I think that a proper gland, fitting into a shallow stuffing box, is a more satisfactory fitting than the conical flange illustrated; it is easier packed and less liable to be done badly.

Having also fitted shafts without liners running in cast iron bushes, I am interested, as other members no doubt will be, to learn Mr. Thornton's experience of them. For sand pump dredgers they lasted longer and gave less trouble than lignum vitae.

Yours faithfully,

JAMES ANDREWS.

The discussion was declared closed.

The SECRETARY stated he had a letter from Mr. Thornton regretting his inability to attend. His reply to the discussion in his paper would be included in the *Transactions*.

On the motion of the VICE-PRESIDENT, a hearty vote of thanks was accorded by acclamation to Mr. Thornton for his paper.

MR. J. M. THORNTON'S REPLY.

TYNE DOCK, SOUTH SHIELDS,

DEAR MR. DUCKITT, *June 18th*, 1901.

I regret that I was unable to be present at the meeting held at Newcastle on the 17th ult. I am glad, however, that a few members have discussed the short paper and agree with the system of keeping the stern tube full of some sort of lubricant so as to keep the water from coming in contact with the tail shaft. I thoroughly endorse Mr. D. Andrew's remarks, where he states "If such means as described were more generally adopted to prevent corrosion, the lifetime of shafts would be considerably lengthened." Mr. Fothergill mentions having a small hand pump fitted in the tunnel recess of two steamers, with excellent results, using a solid lubricant. This system, of course, is perhaps better, "if attended to," but the reason I put the filling pipe aft is that the use of it is not so liable to be neglected. Mr. James Andrews also speaks of a small hand pump in the tunnel recess. For muddy or sandy waters, it is generally admitted that shafts without brass liners, and running on cast iron bushes are distinctly preferable. The writer's experience is that when brass is running on lignum vitæ in such waters, the bearing wears down quickly, and thus strains the shaft, whereas a long bearing of cast iron lasts much longer. In conclusion, I can only repeat that if stern tubes are kept full of some sort of lubricant, whether put in by hand pump or gravity, and the stern gland kept tight, the corrosion of tail shafts in the tubes is practically impossible, and that the bush lining will last much longer.

Yours faithfully,

J. M. THORNTON.

CLOSING BUSINESS.

APPOINTMENT OF AUDITORS.

On the motion of MR. E. GRIFFITH, seconded by MR. A. S. SCHAEFFER, MR. R. W. SISSON was re-elected auditor.

COUNCIL VACANCIES.

The VICE-PRESIDENT declared the names of the gentlemen elected to fill the vacancies in the Council list as follows :—

President—MR. HENRY WITHY.

Vice-Presidents—Messrs. H. B. ROWELL, A. G. SCHAEFFER, and G. W. SIVEWRIGHT.

Hon. Treasurer—MR. G. E. MACARTHY.

Ordinary Members of Council—Messrs. J. H. HECK, R. H. MUIR, E. W. DE RUSSETT. R. WALLIS, and G. D. WEIR.

THANKS TO MEMBERS OF COUNCIL.

Mr. M. C. JAMES proposed a vote of thanks to the retiring members of Council. Only those who had served on it, he said, could appreciate the amount of work done by the Council, and those gentlemen who retired at this period had done their duty very well. He was sure they were pleased to see some had been promoted to be vice-presidents.

Mr. G. ARNISON seconded.

The VICE-PRESIDENT, in putting the vote of thanks to the retiring Members of the Council to the meeting, said he hoped the meeting would carry this vote by acclamation. The council always regretted when members of their body retired, but they realised it gave opportunity to infuse new blood which should prove beneficial to the best interest of the Institution.

The vote of thanks was cordially received and approved.

The VICE-PRESIDENT then declared the business proceedings of the session closed, and in doing so thought they might congratulate themselves on the success of the session, the high standard of the papers read, and the useful and practical discussions which had taken place. He thought much of the success of the Institution, and the application for copies of the *Transactions* of the Institution showed how much the papers were appreciated, was largely due to the sound practical information given, the outcome of large experience in everyday work and level-headedness of the Engineers and Shipbuilders of the North East Coast. He also desired to call the attention of the members to the forthcoming visit to the works of Messrs. Bell Brothers and Messrs. Dorman, Long and Co., Middlesbrough.

The session was then closed.

VISIT TO MIDDLESBROUGH ON TEES.

MAY 23RD, 1901.

In response to an invitation received from Messrs. Dorman, Long & Co. and Messrs. Bell Brothers, the Institution visited the Britannia and Clarence Works on Thursday, May 23rd, 1901. Over 200 of the members assembled at the Railway Station, Middlesbrough, at 11 a.m., the majority having been conveyed by a special train from Newcastle-upon-Tyne and Sunderland, and were met by Mr. W. H. Panton, managing director of Messrs. Dorman, Long & Co., Mr. J. H. Gunter, general manager, etc., and were conveyed in brakes to the works of Messrs. Dorman, Long & Co. Under the guidance of Mr. W. H. Panton, Mr. J. H. Gunter, Mr. C. H. F. Bolckow and other officials, the visitors were conducted over the sheet mills and galvanising and corrugating shops. They then retired for lunch provided by the firm.

At the conclusion of the luncheon, Mr. J. R. FOTHERGILL (senior Vice-President of the Institution), apologised for the absence of Mr. H. Withy, the President, and proposed success to the firm, coupled with the health of Mr. Panton. This toast having been musically and heartily honoured, and Mr. Panton having responded, the Britannia Works of Messrs. Dorman, Long & Co. were visited.

The party were conducted over the girder shops, in which huge overhead travelling cranes were swinging about 25-ton girders. The largest and most modern wire works in the world were then visited, and demanded special attention. Bars of metal, 28 feet long, with a cross section of two square inches, were fed into the machines, and on emerging, as the finished article, were upwards of half-a-mile in length. The galvanising of this wire, the manufacture of barbed wire, and the making of wire ropes, were all operations of interest, exciting the admiration of the beholders. Several samples of wire were on exhibition, one sample measuring seven miles in length, and weighing but 200 pounds. One piece of wire, about 1-12th of an inch in diameter, was carrying a weight of 1,236 pounds, equal to 100 tons per square inch.

At 3·30 p.m. the party were taken down the river in the Tees Conservancy Commissioners' steamer "Sir Joseph Pease" to the Clarence Works of Messrs. Bell Brothers.

On arrival at Port Clarence, the visitors were met by Sir Lowthian Bell, Bart., and Colonel C. L. Bell, who extended to them a hearty welcome. Sir Lowthian in the course of a short address, said:—There is no one here, perhaps, whose mind can travel further back and trace the gradual progress of iron shipbuilding than I myself can. I was present at the launch of the very first iron ship built on the Tyne, adjacent to the works of which I subsequently became the managing partner. You have come over here into a district where the material you require for building your ships is to be found, and was found in the greatest plenty. Knowing that, I have steadily kept before me the utilisation of that ironstone for every purpose for which iron is required. I never ceased believing that the day would come, in spite of the great difficulties attending the manipulation of our native ore, when we would learn to get rid of that which was the stumbling block and barrier to further progress. Twenty years ago, or more, I commenced my experiments and researches upon the nature and constituents of our ironstone, and I saw quite well that we were rapidly approaching the time when our own ore, without any admixture, would be used for making iron. That day has come. You will find comparatively impure iron converted into plates which satisfy the stipulations of Lloyds' surveyors. We can congratulate ourselves upon having gained everything which, twenty years ago, I expected would happen. Let me congratulate you on the great progress you on your part have made in steam navigation. The first time I crossed the Atlantic they were burning 190 tons of coal a day, and driving the vessel at half the speed attained now with about 70 tons of coal a day. All that has not been achieved without great thought and the application of great science, embodying those principles without which you cannot hope for success. I cannot tell to what extent progress has yet to go.

Sir Lowthian was heartily cheered, both at the commencement and conclusion of his address.

Mr. J. R. FOTHERGILL, in the absence of the President, tendered the hearty thanks of the Institution to Messrs. Bell Brothers and to Sir Lowthian Bell, Bart., for the invitation to visit the Clarence Works

Not only did they appreciate the invitation, but they very fully appreciated the honour Sir Lowthian paid them by his personal presence in receiving them. It was no light matter at Sir Lowthian's age to undertake the journey he had done for the purpose of being present. They all hoped he would not feel any fatigue from the exertion, but that he would for some years to come enjoy good health. They had listened with interest to the address Sir Lowthian had given, and he asked the members present to express by acclamation their appreciation of the invitation to visit the Port Clarence Works.

This was enthusiastically carried by the members.

The Clarence Ironworks were then subjected to as equally an exhaustive inspection as that undergone by Messrs. Dorman, Long & Co.'s works, the visitors again finding everything of interest. The latest form of German coke oven was carefully inspected, and highly praised.

On the conclusion of the tour, tea was served, and the visitors shortly afterwards left for home, having spent a most enjoyable day. Each visitor was presented with a handsome souvenir of the day's visit, in the shape of a finely-printed and illustrated book, containing a history of each of the firms, together with excellent views of the works.

DORMAN, LONG & CO. LIMITED. (See Plate XXII.)

Historical.

In the year 1876 Messrs. Arthur John Dorman and Albert De Lande Long went into partnership and took over the West Marsh Works which belonged to the West Marsh Iron Company. These works consisted of 20 puddling furnaces with a shingling hammer, a puddled bar rolling mill and a 14-inch finishing mill to which they added a 10-inch mill. The product of the works was principally iron bars and angles used for shipbuilding purposes which were made from old iron rails and puddled bars. Owing to the supply of old rails running short, the firm, which was then known as Dorman, Long & Co., leased the Britannia Ironworks in 1879. These works were built by Sir Bernard Samuelson in 1872 for rolling iron rails, but as steel gradually superseded iron these works had become unprofitable and were not working at the time Dorman, Long & Co. took them over.

It was first intended simply to make puddled bars at the Britannia Works, to be rolled into finished sections at the West Marsh Works, but the business of the Company increased so rapidly that it was decided to roll the larger sized angles in the old rail mill which was then a simple "pull over" mill driven by a fly wheel engine. In 1881 a reversing engine was put down to drive this mill, and in 1882 a larger mill was put down on the other side of the engine with 32-inch rolls.

At the Britannia Works there were 120 puddling furnaces, but in 1886 half of these were pulled down and 7 Siemens-Martin open hearth steel furnaces erected in their place. Subsequently the whole of the puddling furnaces were pulled down and replaced by steel furnaces until at the present time there are 11 furnaces.

In 1889 these works were turned into a limited liability company under its present style of Dorman, Long & Co., Limited. Mr. Arthur John Dorman and Mr. Albert de Lande Long continued to act as Managing Directors till 1891, when Mr. William Henry Panton was appointed general manager. Mr. Long retired from the active management of the works but still remained as a member of the Board, from which he ultimately retired in 1900, when Mr. Panton was elected to the Board and he and Mr. Charles Dorman were appointed managing directors, Mr. Arthur John Dorman remaining as chairman. The sheet works and the wire works were incorporated in January, 1899.

The sheet works originally belonged to Messrs. Jones Brothers, and for many years were carried on by Mr. Arthur John Dorman and his brother, the late Mr. Robert Page Dorman. These works lie on the east side of the Britannia Works being separated by the North Eastern Railway.

The wire works were originally started by the Bedson Wire Co., and and afterwards carried on by Mr. Arthur John Dorman for some years under the name of Charles Dorman & Co. These works adjoin the Britannia and West Marsh Works and are connected by railways.

The development of the girder trade has been one of the principal features of the Company. In 1883 the first girders were rolled at the Britannia Works. Up to this time girders had almost been exclusively made in Belgium and Germany. They were first made of iron, but as a supply of steel was got from the new steel furnaces the manufacture of iron girders ceased entirely. The largest sizes are rolled and for some time the Company have been the most extensive producers of girders in this country.

The steel used was originally made from hematite iron which was manufactured at the local blast furnaces from Spanish ore. In 1894

Mr. Panton made his first attempt to produce steel from Cleveland iron, using one of the furnaces at the Britannia Works. The results warranted his taking the experiments further, and in 1897 another attempt was made at the Roseberry Foundry which was then the property of Messrs. R. P. Dorman & Co., and is now the property of Messrs. Dorman, Long & Co., Limited. These experiments having been successful Sir Lowthian Bell kindly put the furnaces, which had been worked some years since at Clarence with the Pourcel process, at the disposal of the Company for further experiments. These furnaces were worked till it was proved that steel could be made profitably from Cleveland iron. This resulted in the firm of Messrs. Bell Brothers, Limited, being turned into a public limited liability company, Messrs. Dorman, Long & Co., Limited, and the family of Sir Lowthian Bell holding in equal proportions the ordinary shares. The developments which have taken place at Clarence consequent on this are fully described on another page.

The manufacture of iron has been entirely given up at the Britannia and West Marsh Works and all material now rolled is made of steel manufactured by the open hearth process, a very large proportion of which is rolled into girders. The bulk of the steel is made from Cleveland iron, partly at the Britannia Works and partly at Clarence, coming from the latter works by barge up the River Tees in the form of ingots.

Owing to the great and fast extending use of steel structures the demand for this class of work has very much increased. Large shops have been erected and a very large staff of men is now employed in drilling, cutting and rivetting the girders up to required forms. Columns and stanchions which in the old days were made of cast iron are now almost exclusively made of steel sections, being chiefly formed of rolled girders.

Descriptive.

The works are situated on the Yorkshire bank of the River Tees, and occupy about 50 acres. As will be seen from the plan, Plate XXII., they are entered from the south side. On the right hand side of the entrance are the head offices, the ground floor of which is occupied by the commercial department, and the first floor by the engineering and works department. The large drawing office is 120 feet by 32 feet in which there are generally 80 draughtsmen employed. Next to the office is a building in which the mechanical tests are taken, and the laboratory. Very careful tests of the iron are made before it is sent up to the furnaces, and of the finished steel after it is made. There are 11 furnaces of various

capacities from 30 to 45 tons. The iron is taken to them up an inclined railway to the charging platform, and the coals for making gas go up a more elevated gantry which is high enough to allow the coals when the bottom of the trucks are open to fall down into hoppers, from which they are automatically fed into the gas producers by a rotary feeder. An analysis of the steel in the furnace is taken before it is cast for carbon, sulphur and phosphorus, so that these elements are brought to their proper limits before the furnace is tapped, which ensures the steel being of the requisite purity. The ingots are all of uniform size, weighing 3¼ tons. As soon as they are cool enough to be moved they are lifted on to bogies and taken with a 3 feet gauge railway to the soaking pits, into which they are lifted by overhead cranes, the same cranes lifting them out of the soaking pits when ready and placing them on live rollers which take them to the cogging mill, where they are rolled into blooms. After the blooms are cut to the required lengths they are put while still hot into wash heating furnaces in the mills, and are then taken to the rolls to be made into finished sections.

The finished bars are cut to lengths as they come hot from the rolls with circular saws. As soon as cold they are taken by overhead cranes to the straightening machines and further forward to be ended and punched if required. They can be loaded on to trucks or taken by overhead cranes to the wharf. The works have an extensive frontage on the river, and large vessels can be accommodated.

The cogging mill has rolls 44-inch diameter driven by a pair of 50-inch cylinder reversing engines. The finishing mill has a reversing engine, 48-inch diameter, 54-inch stroke, which can work the 32-inch mill on one side or the 28-inch mill on the other. These two mills are worked alternately, and when material is being rolled in one mill the rolls are changed in the other. At the other side of the 28-inch mill there is another 48-inch reversing engine which is used when long lengths are being rolled in conjunction with the other engine, one doing the roughing and the other the finishing. The three engines were built by Messrs. Davy Brothers of Sheffield.

At the north west side of this mill there is the Britannia Iron Works electric power station where the electricity is generated to drive all the subsidiary machines. These machines were originally driven by small steam engines which have now been replaced entirely by electric motors. The electric generators consist of three dynamos, each of 160 E.H.P., driven with a Bellis enclosed type engine; and a Mather and Platt dynamo, generating 400 E.H.P. has just been added, driven by a marine type triple expansion engine.

At the north-west corner of the works is the first girder riveting shop that was put up in the year 1890. The demand for structural steel work having considerably outgrown the capacity of this shop, large new shops were erected in 1900 at the south-east side of the West Marsh Mills. These shops are 500 feet long and have two spans of 60 feet and one of 70 feet, having electrically driven overhead cranes of various capacities from 5 to 25 tons. The cranes have a separate motor for each motion and work at a very high speed. The machinery and tools are of the most modern type and the highest class of work is turned out. During last year, 1900, nearly 30,000 tons of structural steel work was made at the Britannia Works. About 600 men are employed upon this branch of the Company's manufactures.

The large sized sections are rolled at the Britannia and the small sizes at the West Marsh Mills. Girders are rolled from 20 inches by 7½ inches, channels from 15 inches by 4 inches and flats from 18 inches downwards, troughing for bridges, zeds, bulb tees, bulb angles, bulb bars, tees, angles, flange and bridge rails, bars, etc.

At the wire works the rods are first rolled in a continuous mill (which was designed by Mr. Philip Bedson) from the billet, 28 feet long 2 inches square, rolling the rods down to No. 6 gauge. This is a very complete mill and will roll rods weighing 400 lbs. The great advantage in this mill being a continuous one is, that it is worked with very little labour and rods can be rolled much longer than can be done in any other mill in the kingdom. After the rods are rolled they are dipped into acid to remove the scale, and then forwarded to the drawing blocks and go through the usual processes of a wire works. All classes of wire are made, from telegraph wire and fencing wire to high carbon wire which is used for making steel ropes. Another small mill has been added which can be used for either rolling wire rods or small sizes of ordinary sections, such as girders, angles, . There are machines for spinning the fencing wire and also for n ing barb wire. All the machines in these works are driven electrica y, except the rolling mills.

The sheet works are on the side of the North Eastern Railway. There are 6 sheet mills, 22 puddling furnaces, 2 shingling hammers and a puddled bar n. T se mills are principally used for making galvanized co for roofing purposes and iron buildings. Both iron and the galvanizing plant is of the works are capable of turning out is galvanized and corrugated.

The three combined works of the Company employ about 3,000 men, and turn out about 3,500 tons of finished material weekly.

A stock of 6,000 tons of girders, channels and flats, is kept at the Middlesbrough Works.

The Company also have large stock yards at Nine Elms Lane, London where they have a commodious wharf on the Thames and the most complete shops for riveting and drilling in the city. About 150 men are employed. The London office is at 19, Victoria Street, Westminster. The Company also have a stock yard at Melbourne, with a regular staff and machinery for dealing with the work there. They also have distributing agencies in India, Africa and Japan.

One important part of the work carried on by the Company is the construction of large engineering works. The whole of the electric works for Messrs. Crompton & Co., Chelmsford, have been constructed by them, the new works for Messrs. Vickers, Son & Maxim, Limited, at Sheffield and Erith, and the Company are now building the new works, at Rugby, for the British Thomson-Houston Co., Limited, and also those for the British Westinghouse Electric Manufacturing Co., Limited, Trafford Park, Manchester. The latter will be the largest engineering works in the world, having a shop floor area of 25 acres in extent, and 14,000 tons of steelwork in the structure. The main part of all these works are constructed of steel, the sides being mere shells of brickwork.

BELL BROTHERS, LIMITED. (See Plate XXIII.)

Historical Sketch.

It is not proposed in the following historical sketch of the Clarence Works to go over the oft-told tale of the discovery of the Cleveland ironstone. It is, however, necessary to mention that the founders were acquainted with the value of the mineral deposits of Cleveland before the discovery of the main Cleveland bed at Eston. The three elder sons of Mr. Thomas Bell, a partner in the firm of Messrs. Losh, Wilson & Bell, had at the death of their father in 1845, succeeded to his interest in the ironworks at Walker-on-Tyne, and the firm of Messrs. Losh, Wilson & Bell were already bringing from the Yorkshire coast ironstone to smelt in a furnace built for the purpose by the present Sir Lowthian Bell. The discovery of this deposit further inland came to them as no surprise, and they were prepared to take advantage of it as soon as the facts became known.

The firm of Messrs. Bell Brothers had been founded in the year 1844 by Mr. Thomas Bell's eldest son, the present Sir Lowthian Bell, and his two brothers, Thomas and John. On the discovery of the Cleveland ironstone at Eston, these gentlemen were, from the circumstances to which we have just referred, quite ready to throw themselves into the new enterprise.

A careful examination of the Cleveland district was made, and without going into elaborate details, it is sufficient to say that an important royalty was secured from those interested in the Normanby Estate. The then tenant for life of this property was not able to lease the minerals underlying his estate without the concurrence of his brothers. One of these, the late Mr. Ralph Ward-Jackson, made it a condition of his consent that the lessees of the ironstone should undertake to build their works on the West Hartlepool Harbour and Railway Company's railway, so that he might secure for the line in which he was interested the carriage of the fuel to the furnaces which were to smelt the ironstone on his family's property. It is due to this circumstance that the Clarence Works were placed in the county of Durham.

Some furnaces were already building on the Tees when the firm of Bell Brothers purchased a plot of land from the owners of the West Hartlepool Railway, and began the erection of the Clarence Works, and in 1854 3 furnaces were blown in. In the first year they made 12,536 tons of iron, which was increased to 15,424 in 1855, and 23,925 in 1856.

At that time the ironmaking industry on the Tees was confined to Messrs. Bolckow, Vaughan & Co.; Messrs. Gilkes, Wilson, Leatham & Co. had just completed the erection of blast furnaces which were blown in a few weeks before those at Clarence.

The condition of trade immediately prior to the erection of the works gave every hope of a prosperous career, but hardly were the works in operation than a severe depression set in, and pig iron fell heavily. The price realised in 1854 amounted to 71s. It fell to 65s. in 1855, recovered a little in 1856, but only to go back to 65s. 5d. in 1857, from which year onwards prices continued to fall till in 1862 they reached 41s.

It is not without interest to mention that the stock of iron held by the firm of Messrs. Bell Brothers in 1861 reached a higher total than at any subsequent time up to 1878. At the first of these dates their yearly production amounted to 46,919 tons, while at the latter it was 195,598.

But it was not only with trade depression that the new enterprise had to strive. The Stockton and Darlington Railway Company and those interested in its prosperity had, as they hoped, secured a monopoly

of the district. The advent of a competing firm, interested in another railway system, was by no means a matter of congratulation to those who directed the affairs of the Stockton and Darlington Railway Company, and a severe Parliamentary struggle ensued,—those interested in the pioneer railway endeavouring to retain their exclusive hold upon the district, while Messrs. Bell Brothers, in co-operation with the owners of the Normanby minerals and others, sought to obtain independent access to the ironstone. This they succeeded in obtaining from Parliament, and the Cleveland Railway was the result. By means of it the ironstone from Normanby was brought to the river side, there put on board barges, towed across the Tees, and delivered at Clarence.

The growing needs of the Clarence Works made it necessary to look further afield for supplies of ironstone, and after further investigations, a lease, from the late Mr. J. T. Wharton, of a large tract of ironstone at Skelton was entered into. In order that this stone might be brought to the Clarence furnaces an extension of the Cleveland Railway was required, and after various Parliamentary contests the right to make a railway extending from the Tees, through Normanby, past Guisborough, to Skelton, and thence to Loftus, was secured.

Their supplies of ironstone being thus made safe, the firm turned their attention to the question of fuel. It is not intended to deal with the chequered career of the West Hartlepool Harbour and Railway Company. Suffice it to say that by this time its course was nearly run, and the liquidators (for it had passed into the hands of liquidators) were disposing of their colliery property in the neighbourhood of Spennymoor.

The Pagebank pit was acquired by Messrs. Bell Brothers, and to it a virgin royalty of 2,000 acres, under part of the estate of the late Lord Boyne, was added. On this, within a few years, the important Browney colliery was sunk. Shortly after this date the Tursdale royalty was purchased from the executors of the late Mr. A. B. Cochrane.

While their mineral resources were thus being secured, the furnaces at Clarence were not neglected. The number had been increased from 3 to 6, which were all built on the old-fashioned model then obtaining. The experiments of the late Mr. John Vaughan on the dimensions of furnaces had directed the senior partner's mind to the same object, and were, in fact, the cause of his exhaustive examination into the theory of the consumption of fuel in the blast furnace. He satisfied himself, both on theoretical and on practical grounds, that furnaces of larger dimensions were desirable, and 2 furnaces, 80 feet high and 16 feet in diameter, were erected at Clarence in the year 1865.

Step by step the old furnaces were replaced by those of the new type, and the Cleveland iron trade still showing capacity for large developments, another plant, consisting of 4 furnaces, was built at Clarence, raising the number to 12.

We have now arrived at the period of unexampled prosperity which succeeded the Franco-Prussian war. The make of iron in the Cleveland district in 1868 stood at 1,233,418 tons. It rose in the year 1869 to 1,459,508; in 1870 to 1,695,377; and in 1871 to 1,884,439; an increase of almost exactly 50 per cent.

The development at Clarence followed very much the same line, the make having been in 1868, 88,470 tons; 1869, 107,201; 1870, 110,980; 1871, 136,997; which is slightly above 50 per cent.

The growth continued at a reduced rate till in 1897 the make of iron in the district amounted to 2,138,378 tons, while that at Clarence had reached 195,598.

Upon this extraordinary increase in production followed a long period of inaction, and indeed no great increase in the make of Cleveland iron has taken place from that day to this. But the practice of the Cleveland ironmasters has by no means stood still. A much larger output has been obtained per furnace, and to compass this a very large expenditure has been necessary.

Five and forty years ago a furnace which produced 150 tons a week was regarded as fulfilling all the reasonable expectations of the ironmaster. Now, 100 tons a day is looked upon as the quantity below which a furnace ought not to fall, and as much as 913 tons a week has been obtained from one of the Clarence furnaces.

These figures are much smaller than those obtained in America, but it would probably be found that if the amount of pig iron made per £ sterling of capital invested in an American furnace and in a Cleveland furnace were compared the comparison would not be unfavourable to the Cleveland furnace. In any case the opinion of the English ironmasters appears to be firmly fixed that it is better to have a great number of somewhat smaller units than to concentrate the make into a smaller number of larger units.

The tendency is, however, now, as in the past, to increase the make of each individual furnace. To do this it has been necessary to spend large sums of money upon the plant outside the furnace stack itself. Blowing engines, boilers, stoves and calcining kilns have all undergone more than one transformation, and these changes are still taking place.

The ground occupied by the 3 furnaces originally built is still

occupied by 3 furnaces, and it says much for the prescience of the designer of the works that the ground on which he contemplated building 8 furnaces, to produce something like 2,000 tons a week, has sufficed for 8 furnaces which are capable of producing well on to four times this quantity.

We have said that the changes are still going on. The visitor to Clarence to-day finds, indeed, 8 furnaces on the old side, of which, however, only 7 are in blast, No. 6 furnace having been recently blown out for repairs. It was replaced by No. 7, built on lines which commend themselves to the management, and so far the result has entirely justified the conclusions to which the engineers had come.

The 7 furnaces are equipped with 20 stoves, and are provided with 16 calcining kilns. The blast is supplied by 5 blowing engines of the following dimensions, three having 42-inch steam cylinders and 100-inch blowing cylinders with a 5-feet stroke, and the other two 36-inch steam and 100-inch blowing cylinders and 4-feet stroke, capable of compressing the air up to 10 lbs. per square inch, the steam being produced in 18 boilers, fired entirely by gas from the furnaces.

On the new side 3 out of the 4 furnaces are at work, the fourth (No. 12) is nearly ready to be blown in. Arrangements are being made to adopt here the American plan of blowing each furnace independently, and it is hoped that by this means a further increase in the quantity of iron produced will be obtained, while the consumption of coke will be lessened.

The new side furnaces, when the alterations at present in progress are completed, will be equipped with 16 stoves, the ironstone being supplied to them from 9 calcining kilns at present, but more are being erected. There will be 5 blowing engines, arranged in such a way that any engine can be utilised to blow any furnace, each delivering 1,600,000 cubic feet per hour of air at a pressure of 20 lbs. per square inch, leaving one engine always in reserve. The steam for the blowing engines is supplied from 9 boilers, fired, as on the old side, by means of gas.

The 2 new blowing engines now in course of erection are compound condensing engines, and it is anticipated that a considerable saving in fuel will be obtained from them, in which case arrangements will be made for the supply of electric power from the steam which the furnace gas produces, and which the blowing engines will no longer require.

The temperature of the blast going into each furnace is taken every two hours by means of a Le Chatelier electric pyrometer, an instrument which measures the electric current generated by heating the contact of

two wires, one being pure platinum and the other that metal alloyed with 10 per cent. of rhodium. The current thus generated is led by wires into the office, where it is read off without the operator leaving the building. A continuous record can be taken of the current by photography. Uehling's pyrometers are also in use at two of the furnaces, but the electric is found to be the best and simplest.

A still more recent development in the Cleveland district is the erection of by-product coke ovens in the immediate vicinity of the furnaces. In co-operation with a German firm, a battery of by-product ovens has been erected at Clarence, and is now producing 1,100 tons of coke a week. In connection with this, elaborate arrangements have been made for the supply of a regular mixture of coal, and for the proper washing of the mixture.

Beside the furnaces, coal washing plant and coke ovens, in the centre of the yard are the necessary mechanical shops where all repairs are done for the Clarence Works, and also for the mines and collieries of the firm, and to the north-east are placed the iron and steel works.

The iron for the steel works is brought direct from the blast furnaces in the molten state and poured from a high level into a mixer capable of containing 300 tons, which is heated by gas from 3 gas producers, whence it is taken on a lower level, to the Siemens-Martin furnaces, of which at present there are 4, each having a capacity of 45 tons. The gas producers are of the same type as those at the Britannia Works, being automatically fed with coal, air being blown into them by Root's blowers.

The ladle containing 25 tons of molten metal from the mixer, on arriving in front of the steel furnaces, is lifted up on hydraulic tables and poured into the furnaces by hydraulic cylinders. In this way the ladle is never suspended and the chance of an accident very considerably reduced.

The ingots are taken direct from the steel works and placed in coal fired soaking pits and then to the rolling mills, which consist of 3 stands of 3-high rolls 32-inch diameter, driven by a vertical compound condensing engine. A 100-ton electrically driven overhead crane is provided capable of lifting a pair of standards and set of rolls complete, so that the mill can be rapidly changed to roll various sections. Duplicate standards are also provided, and a set is always ready fit up with rolls and guides for the next section to be rolled. The blooms are cropped and cut to the required lengths by a pair of specially designed hydraulic shears. The blooms then go on to electrically driven transfer-

tables which move them to each pass in the rolls. When the finished bar is rolled it is taken by live rollers, also electrically driven, to the hot saws. There are two "hot banks," one for heavy and the other for light sections, and two saws, the second one being placed 291 feet from the rolls. Two overhead gantries are provided, with electric cranes, which take the bars from the hot banks to the straightening and ending machines, all of which are driven electrically.

MEMOIRS.

MR. JOHN YOUNG SHORT.

Mr. JOHN YOUNG SHORT was born at Pallion, near Sunderland, in the year 1844, and received his education at Pybus' Academy, West Boldon. On leaving school he entered the offices of Messrs. Greenwell, timber merchants, as an apprentice. At the age of twenty-one years, he, in conjunction with his brother, commenced business as a shipbuilder and timber merchant at Pallion, under the style of Short Brothers. In the year 1870 they commenced to build iron vessels. This firm had, up to the time of Mr. Short's death, built about 300 steamers. In the year 1879 Mr. Short received a gold medal and the freedom of the Shipwrights' Company in a competition held in London for the best designed cargo steamer. Besides occupying a high position as a shipbuilder, Mr. Short was one of the largest shipowners in Sunderland, being a partner in the firm of Messrs. James Westoll; and he was also Chairman and Director of several shipping companies in London. He was more or less connected with many of the great commercial enterprises of the district, and he was also one of the principal underwriters in the United Kingdom. In March, 1898, he was elected Chairman of the Sunderland Shipowners' Society, which position he held up to the time of his death. He was a member of the Sunderland Town Council from 1887; and also a member of the River Wear Commission, and as Vice-chairman of the Works Committee he took an active interest in all matters coming before that body. He was a Justice of the Peace for the County of Durham and the North Riding of Yorkshire. He was a strong advocate for the eight hours' working day, and was the first shipbuilder to adopt it.

He died very suddenly in his office, John Street, Sunderland, on the afternoon of January 24th, 1900, being at the time engaged in conversation with Mr. William Allan, M.P. for Gateshead.

Owing to his sterling business qualifications and courteous manner he had many admirers, by whom his loss will be greatly felt. He became a member of this Institution at its formation in 1884.

MR. GEORGE NOBLE.

Mr. GEORGE NOBLE was born at Penshaw, Durhamshire, in the year 1842. He served his apprenticeship with Messrs. George Clark of

Southwick, Sunderland. Subsequent to this he was for twelve years engaged as a sea-going engineer. Afterwards he was appointed superintendent engineer to the late Mr. Arthur Pring, shipowner, of Newcastle-upon-Tyne. On leaving Mr. Pring's employment, he commenced business as consulting engineer, and acted as representative for the firm of Messrs. Charles Cammill & Co., Cyclop's Works, Sheffield, in Newcastle-upon-Tyne and district up to the time of his death. He also interested himself in sending a number of local engineers to Egypt for Messrs. Cook & Sons, tourist agents, for employment in their boats on the River Nile.

For some time prior to his death he was a great invalid, being troubled with a severe affliction which he bore with fortitude, being always of a cheerful disposition. He was a genial companion, a warm friend, and ever ready to assist the young engineers who came within his circle. He joined the Institution in 1893, and though he took no active part in its working yet he was a strong supporter of it, and took more than a passive interest in its concerns.

He died at Tynemouth on the 18th day of January, 1901.

MR. FREDERICK ROBSON.

MR. FREDERICK ROBSON was born in Newcastle-upon-Tyne in the year 1844. His father, Mr. Robert Robson, who was a cabinet-maker, was the founder of the firm of Messrs. Robson & Sons, Northumberland Street, Newcastle. On leaving school Mr. F. Robson was apprenticed to Mr T. B. Winter, optician, Newcastle, on the completion of which he went to London, sought and obtained employment with the well-known firm of scientific instrument makers and opticians, Messrs. W. F. Stanley & Co., London, with the view of further improving himself in his profession.

He afterwards returned to his native city and opened a business in Dean Street. His success was such that in a few years he was obliged to take larger and more commodious premises. He was the inventor of several improvements in surveying and optical instruments.* He joined this Institution in 1887 as an associate member and took a great though passive interest in its workings. He never took any prominent part in public matters, being of a retiring disposition. His chief hobby was

* Prior to his death he took into partnership Mr. J. B. Young, who about thirty years ago came to Mr. Robson as an apprentice, afterwards acted as manager, and by whom the business is now carried on.

horticulture, and as a grower of roses he was unsurpassed in the district, and his advice in such matters was in constant request.

For some months previous to his death he was in very indifferent health and for this reason he went to Bath to take the waters. Unfortunately he caught a chill while there, which brought on an attack of pneumonia and caused his death, which took place on the 22nd of February, 1901. He was of a very sympathetic nature, ready to assist those in distress, but always in a quiet and unostentatious manner.

MR. GEORGE CLARK.

Mr. GEORGE CLARK was born in North Bridge Street, Sunderland, in June, 1842. He served his apprenticeship in his father's works, which were then situated in North Bridge Street, where the Manor Offices now stand, after which he spent a few years with Messrs. Penn's, engineers, Greenwich. When about twenty-one years of age he returned to Sunderland and took over the sole management of his father's works, which were subsequently removed to Southwick, where under his guidance they gradually developed to the important position they now hold. In public life Mr. Clark served for a short time in the Sunderland Town Council, and for about six years he represented Southwick in the Durham County Council. While associated with the County Council he interested himself chiefly in the educational part of the work. He also held a high position in connection with the engineering industry of the North East District, taking an active part in all questions connected with the Engineering Federation of Employers. He was held in the greatest esteem by his fellow-employers, and also by the workmen and their leaders, and his judgment in all cases of dispute was accepted with confidence by both sides.

He was a member of the Institution of Naval Architects, the Institution of Mechanical Engineers, and for a number of years was a Vice-president of this Institution, in which he took considerable interest, having been a member since its formation in 1884. About fifteen years prior to his death he underwent a surgical operation for an internal complaint, since which time his health had been somewhat indifferent. He died suddenly at Mentone, in the south of France, on the 4th day of March, 1901.

His unostentatious manner and kindly disposition won him many friends, and his unexpected decease was deeply felt by all with whom he was associated.

MR. ARTHUR LAING.

MR. ARTHUR LAING was born in Sunderland on the 18th of January, 1856. He was educated at Wellington College, Berkshire. On leaving school he entered the Sunderland works of Messrs. The North Eastern Marine Engineering Co. as an apprentice. On the completion of his apprenticeship he went to sea in the s.s. "City of New York," belonging to the Inman line of steamers. He afterwards joined his father's shipyard at Deptford, Sunderland, and assisted greatly in the development of the brass foundry connected with that establishment, and latterly he was connected with the management of the shipyard. He was also interested in a number of shipowning companies. He held the position of managing owner of the "Dale" line of steamers, and was likewise a director of the Neptune Steam Navigation Co. He joined this Institution at its formation in 1884, took a keen interest in all its workings, and was for many years a vice-president, which position he held at the time of his death, which took place on the 16th of March, 1901.

SIR RAYLTON DIXON.

SIR RAYLTON DIXON was the son of the late Mr. Jeremiah Dixon of Balla Wray, Ambleside. His father, having settled in Newcastle-upon-Tyne, held for some time a responsible position in connection with one of the banking firms of the city. Sir Raylton was born in Newcastle in the year 1838. After receiving a liberal education at private schools he, at an early age, entered the shipbuilding yard of Messrs. Coutts & Parkinson at Willington Quay-on-Tyne as an apprentice, and in the year 1856, on the termination of his apprenticeship, he took up a position with Messrs. Charles Mitchell & Co., now Messrs. Sir W. G. Armstrong, Whitworth & Co., Walker Shipyard, Walker-on-Tyne. In 1859, the year in which he attained his majority, he left the Walker Shipyard and removed to Middlesbrough to take up the position of manager of the Cleveland Shipyards, a branch establishment started by Messrs. Richardson, Duck & Co. of Thornaby. At the end of four years Sir Raylton, then Mr. Dixon, entered into partnership with Mr. Backhouse and took over the Cleveland Yard, in which they carried on a successful business up to the year 1873, when Mr. Backhouse retired and Mr. Dixon was left the sole proprietor of the yard, since which time up to his death he has conducted the business, both as his own and as a limited company, with the greatest possible success. For many years it has been looked upon as the most

important shipyard on Tees-side. The firm has constructed sundry gunboats for the British Government, many large merchant steamers, and lately two very fine steamers for Messrs. Elder, Dempster & Co. of Liverpool for their West Indian fleet.

Sir Raylton took a keen interest in the progress and welfare of the town of his adoption. In 1868 he was elected a member of the Town Council of Middlesbrough, the year in which the park given by the late Mr. Bolckow to the town was opened by H.R.H. Prince Arthur. He retained his seat until 1887, when he retired; but in the following year he was elected to fill the position of Mayor. During his year of Mayoralty the new Town Hall and Municipal Buildings were completed, and the borough was honoured by a royal visit from His Majesty King Edward VII. and Her Majesty Queen Alexandra, then the Prince and Princess of Wales, who came to the town to open the magnificent pile of buildings of which Middlesbrough may be justly proud. The Royal visit proved a memorable event in the annals of the town. As Mayor and Mayoress Mr. and Mrs. Dixon won the approbation and esteem of all for their generosity, hospitality and philanthropy. On New Year's day, 1890, Her late Majesty, Queen Victoria, conferrred upon him the dignity of knighthood, an honour the news of which was received with the greatest satisfaction and appreciation by both public and private friends, who warmly congratulated the recipient and Lady Dixon. In the same year, 1890, in appreciation of his many services rendered to the town, Sir Raylton was presented with the freedom of the borough.

For some years he sat as a member of the Board of Guardians. He also represented the Middlesbrough Shipowners on the Tees Conservancy Commission, having been elected in 1898.

In 1872 he was appointed a Justice of the Peace for the borough, and was placed upon the Commission of the Peace for the North Riding of Yorkshire in 1885. He was a vice-president and life-governor of the North Riding Infirmary, and for some years he sat on the Council of the North Ormesby Cottage Hospital. For eighteen years he held the rank of Major in the 1st North Yorkshire Artillery Volunteers, and when he resigned his commission in 1886 he received permission to wear the uniform. He was a member of the Council of the Institution of Naval Architects, and since the year 1888 he has been a member of this Institution.

During the forty-two years Sir Raylton was settled in Middlesbrough he laboured unceasingly, unsparingly and strenuously for the advancement both socially and industrially of the town he had made his home. In

his public functions he proved himself a faithful and unselfish servant. He was ever ready to help the needy, comfort the afflicted and suffering and feed the hungry, and was always willing to do what lay in his power for the good of his fellow-townsmen.

For some years previous to his death he suffered from a painful and incurable complaint to which he succumbed on the 28th of July, 1901, at his residence, Gunnergate Hall, Marton, near Middlesbrough. His death, though not unexpected, led to sympathetic expressions of regret and sorrow throughout the district, where the loss of his cheerful countenance, and genial and sympathetic influence will long be felt.

APPENDIX.

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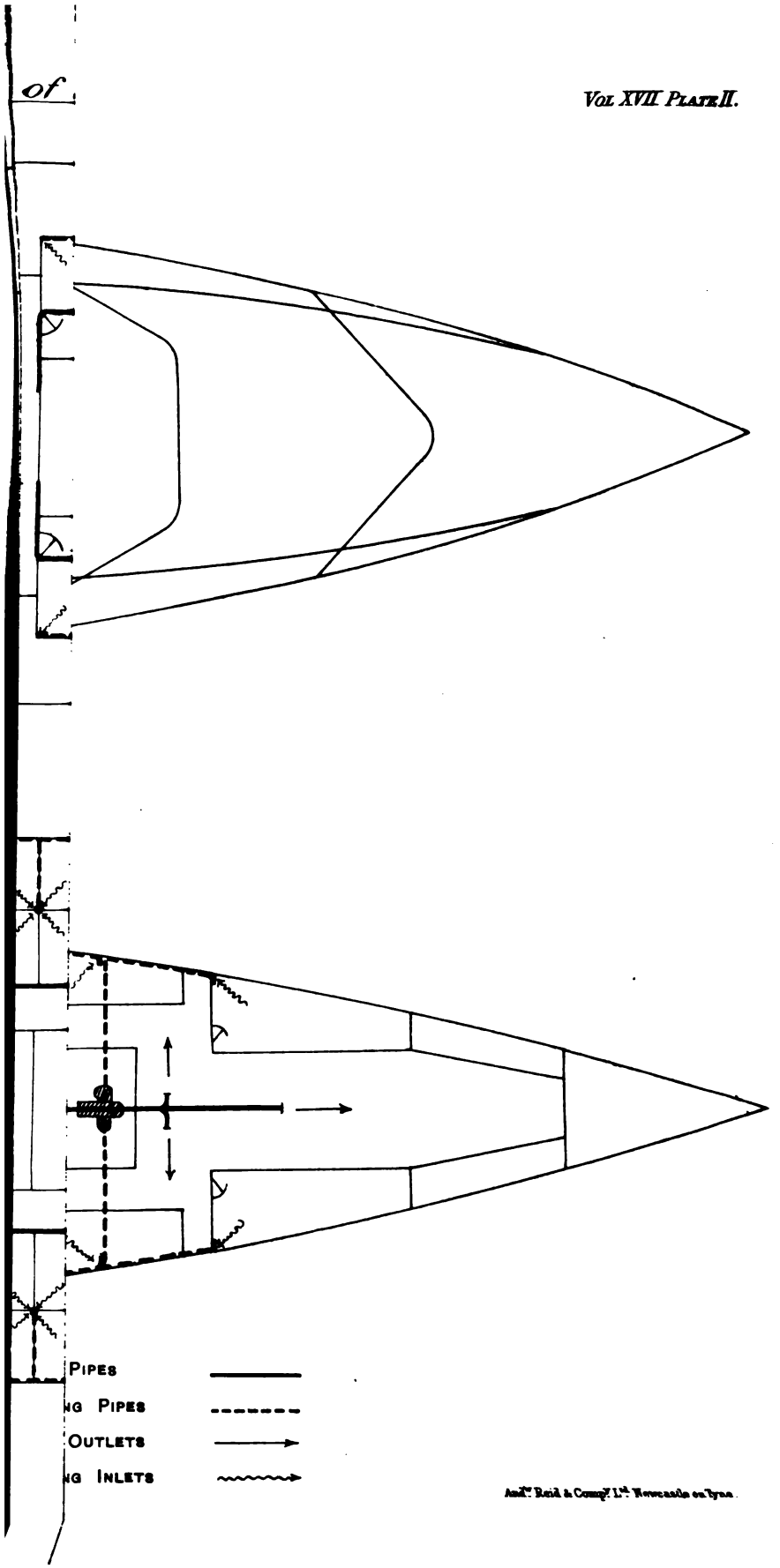

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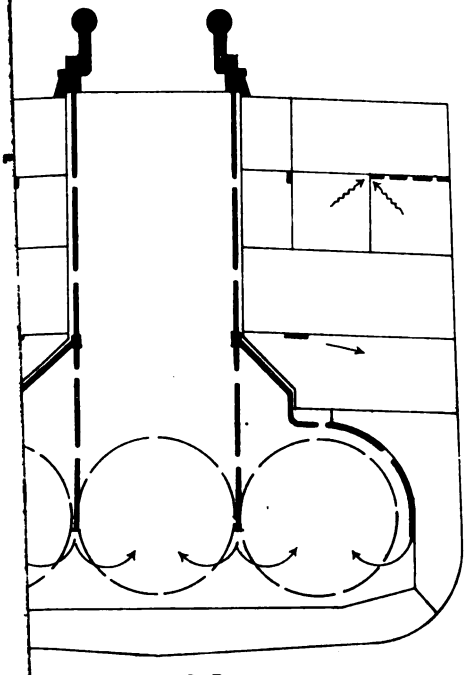

Fig. 9.

Section, C-D.

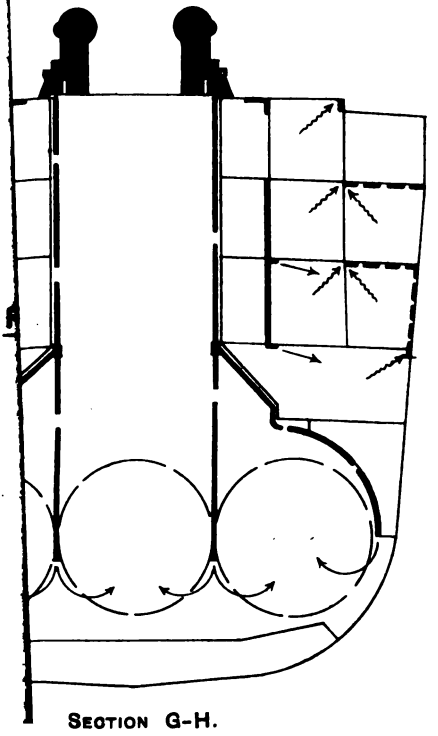

Fig. 10.

Section G-H.

Press.

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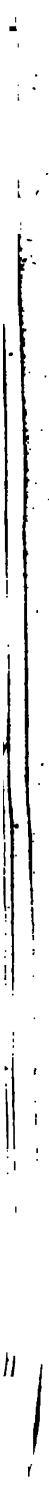
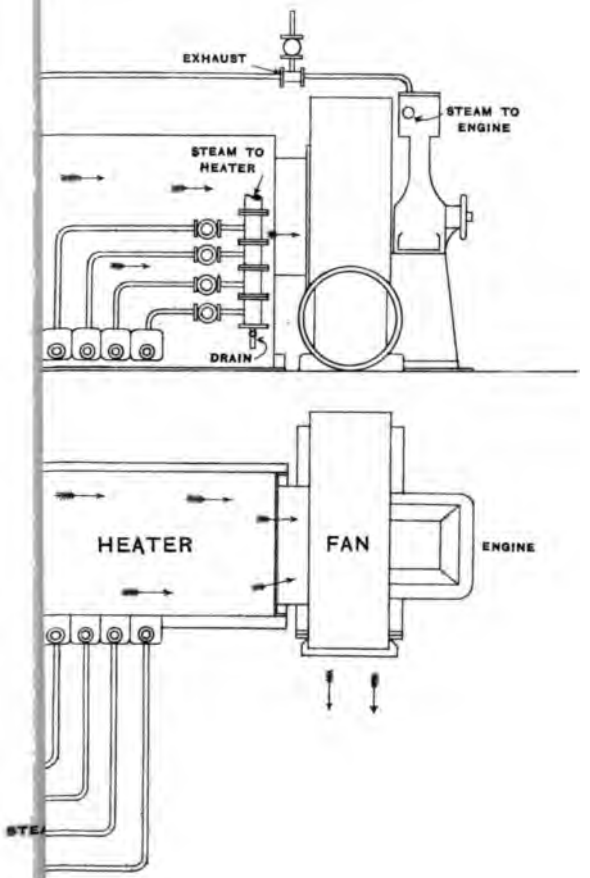
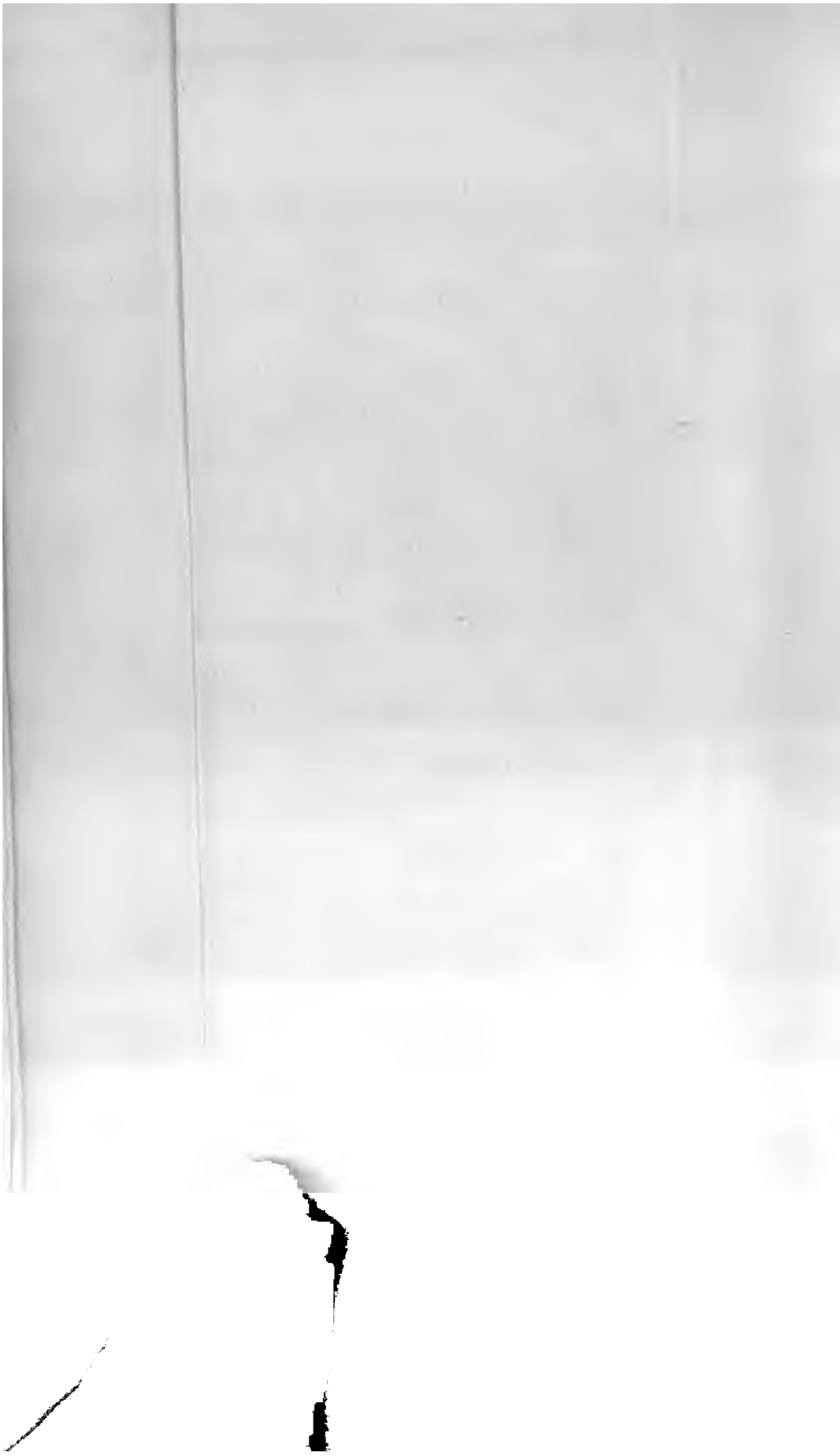


FIG. 12.

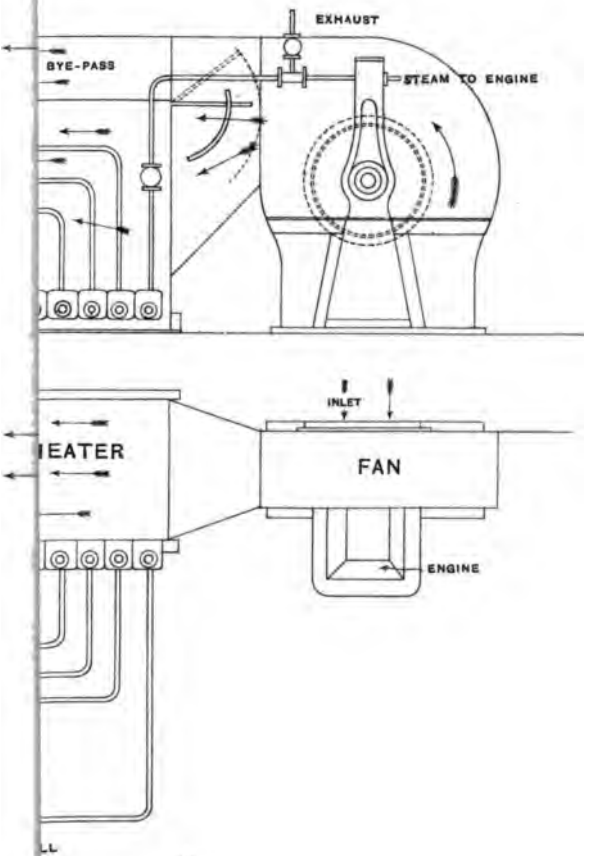


STEAM FAN AND DRAW-THROUGH HEATER.

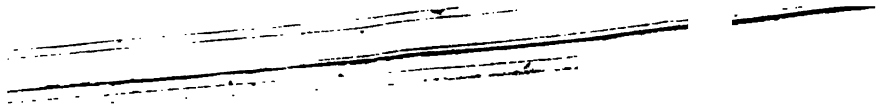
And.ᵂ Reid & Comp.ʸ L.ᵗᵈ Newcastle on Tyne.



G. 14.



AND BLOW-THROUGH HEATER,
T AND COLD AIR SYSTEM.



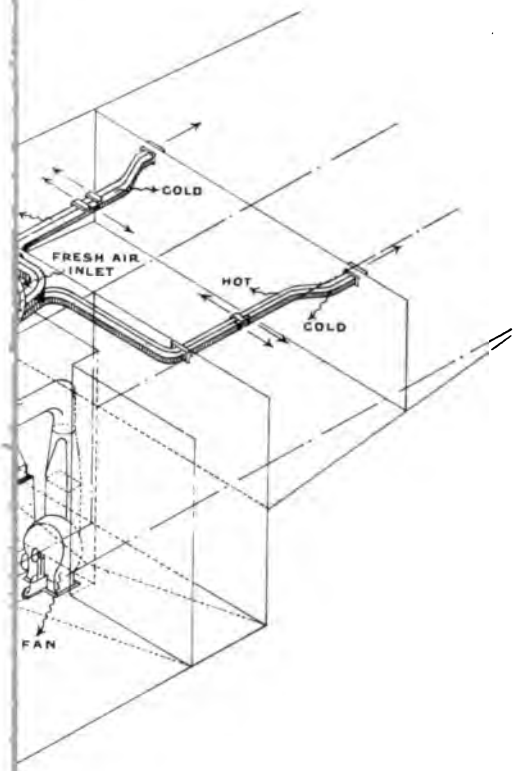


FIG. 21.

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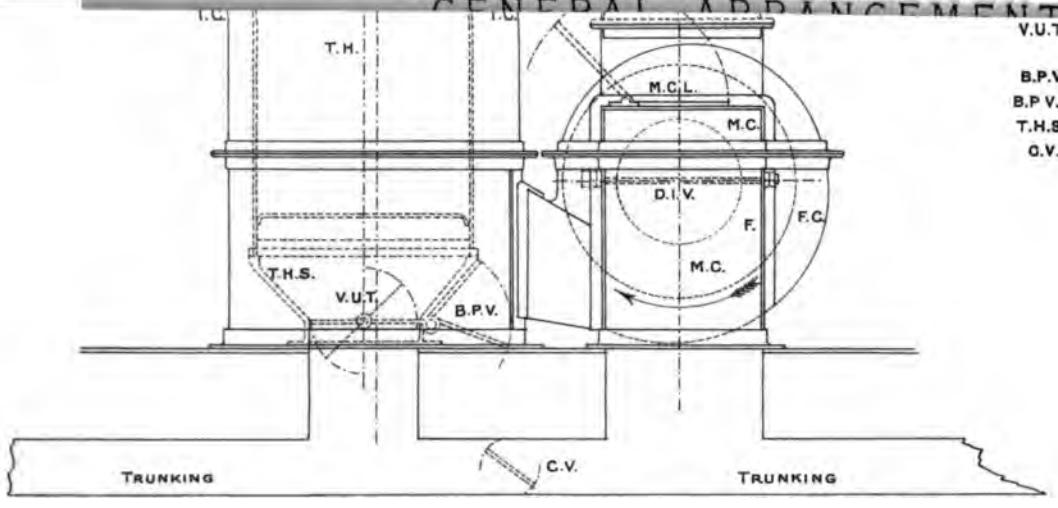
To illustrate Mr. W. Maxwell Stewart's Remarks on Mr. F. W. Jenning's Paper on "The Ventilating and Heating of Ships".



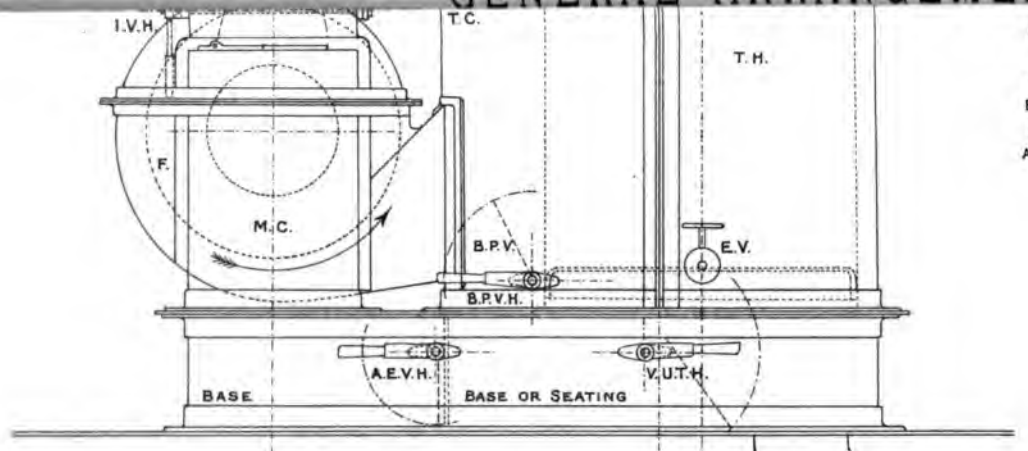
V.U.T. „ VALVE UNDER THERMOTANK HEATER OR INLET VALVE TO TRUNKING.
B.P.V. „ BYE PASS VALVE.
B.P V.H. „ BYE PASS VALVE HANDLE.
T.H.S. „ THERMOTANK HEATER CASING.
C.V. „ CIRCULATING V. LVE.

Proceedings N.E.C.I of E & S 1900-1
Session XVII.

And.w Reid & Comp.y L.td Newcastle on Tyne

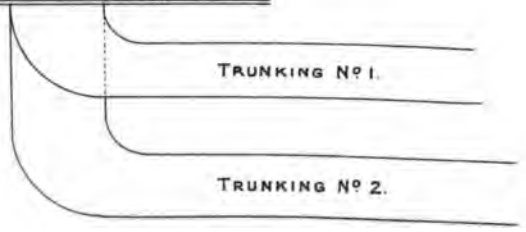
To illustrate M.r W. Maxwell Stewart's Remarks on M.r F.W. Jenning's Paper on "The Ventilating and Heating of Ships".

GENERAL ARRANGEMENT



O.V. „ Outlet Valve (Exhaust).
V.U.T. „ Valve under Thermotank Heater or Inlet Valve to Trunking No. 1, No. 2.
B.P.V. „ Bye Pass Valve No. 1, No. 2.
B.P V.H. „ Bye Pass Valve Handle.
A.E.V. „ Air Exhaust Valve No. 1, No. 2.
A.E.V.H. „ Air Exhaust Valve Handle.

Arranged for giving Two Supplies of Air, both Supplies capable of being Regulated (independently) in Volume and Temperature.



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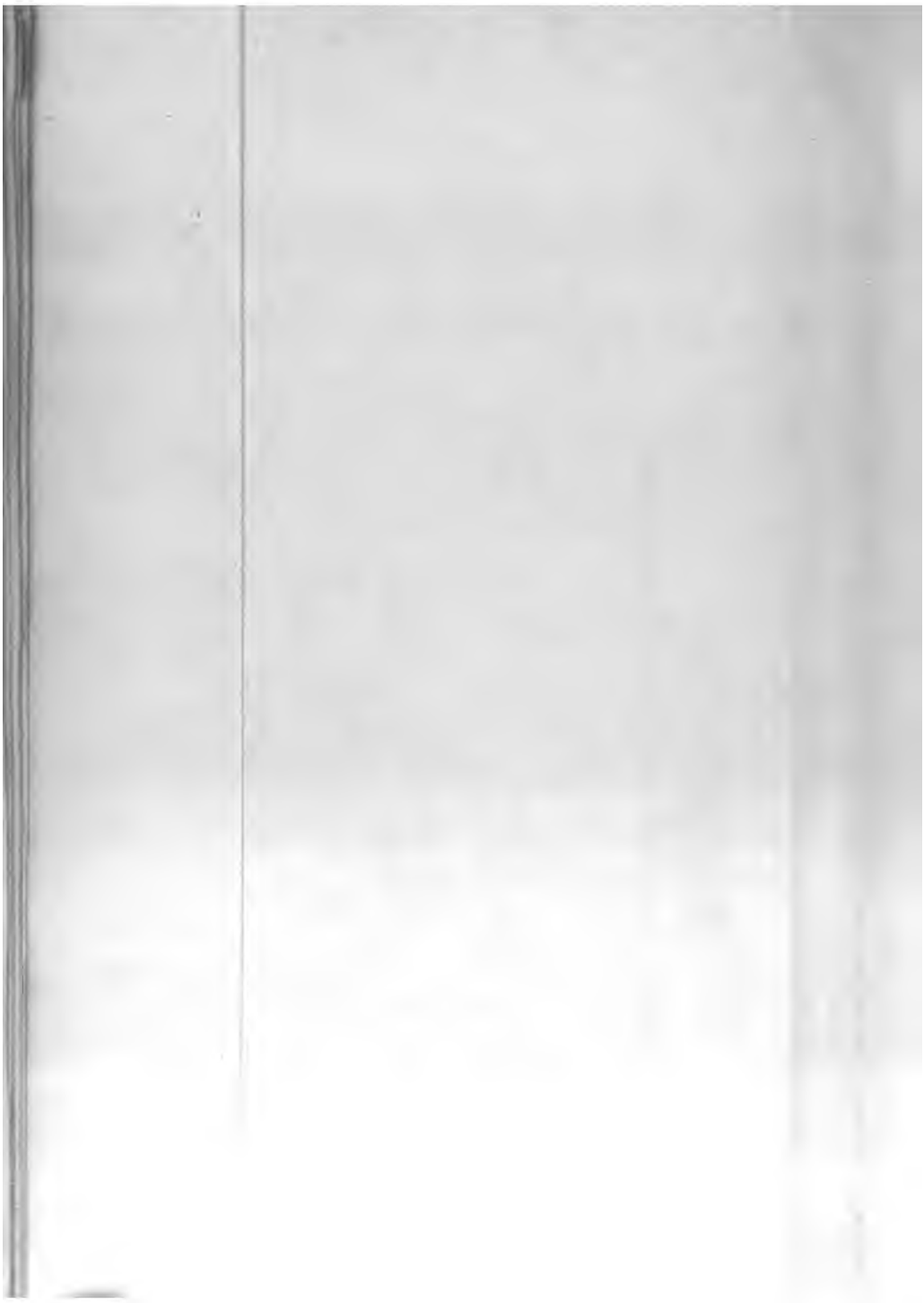
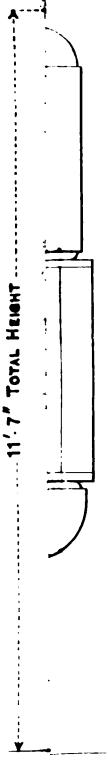
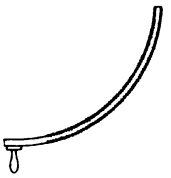




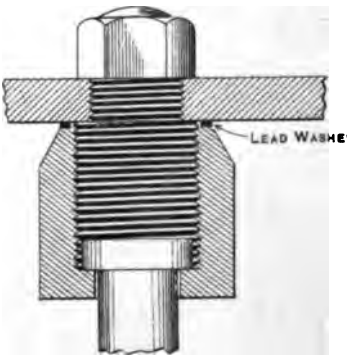
		ORDINARY BOILER, 10 6 X 10 0	CUMMINS' BOILER.
WORKING PRESSURE		160 LBS.	250 LBS.
HEATING SURFACE		900	900
GRATE SURFACE		30	30
VOLUME OF FIRE BOXES		97 C. FT.	97 C. FT.
STEAM SPACE		140 C. FT.	140 C. FT.
AREA THROUGH TUBES		5·25	5·25
MEAN DISTANCE TRAVELLED BY GASES FROM FIRE-BARS TO UPTAKE		14' 0"	16' 0"
WEIGHT OF WATER OVER HIGHEST HEATING SURFACE		1·8 TONS	1·0 TONS
SPACE OCCUPIED	LENGTH	10' 6"	10' 6"
	BREADTH	11' 0"	8' 6"
	HEIGHT	11' 7"	11' 7"
WEIGHTS.	BOILERS, UPTAKE & TUBE CASING	23·78	11·32
	FIRE-BARS, FRONTS AND BRIDGES	2·10	3·20
	FIRE-BRICKS	·50	1·78
	CLEADING	1 01	·50
	WATER	11·53	3·42
	TOTAL	38·92	20·22



SKETCH OF TUBE BRUSH.

HALF-PLAN LOOKING ON UPPER DRUM.

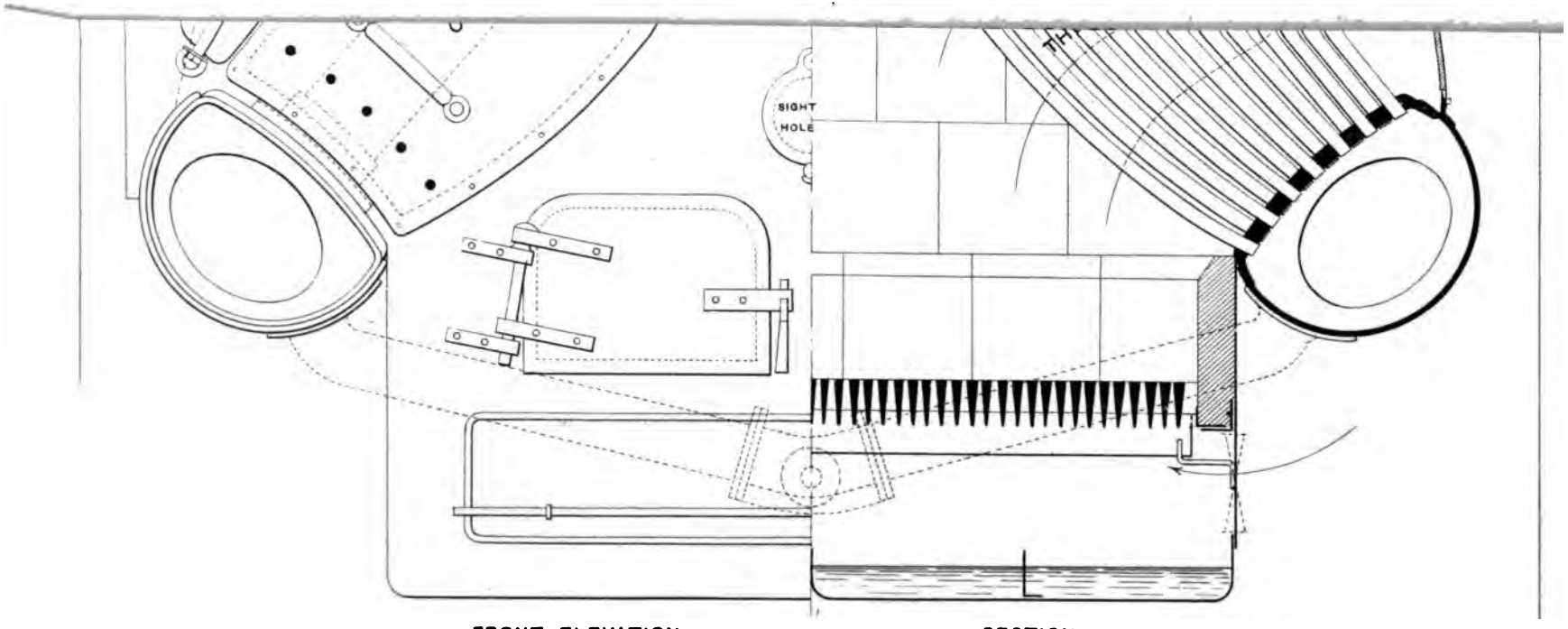
HALF-SECTION THROUGH LOWER DRUM.



DETAIL OF PORTABLE STAYS.

Proceed

To illustrate Messrs J. Samuel White & Company's Communication on Mr. E. Griffith's Paper on "Water Tube Boilers."



FRONT ELEVATION. SECTION.

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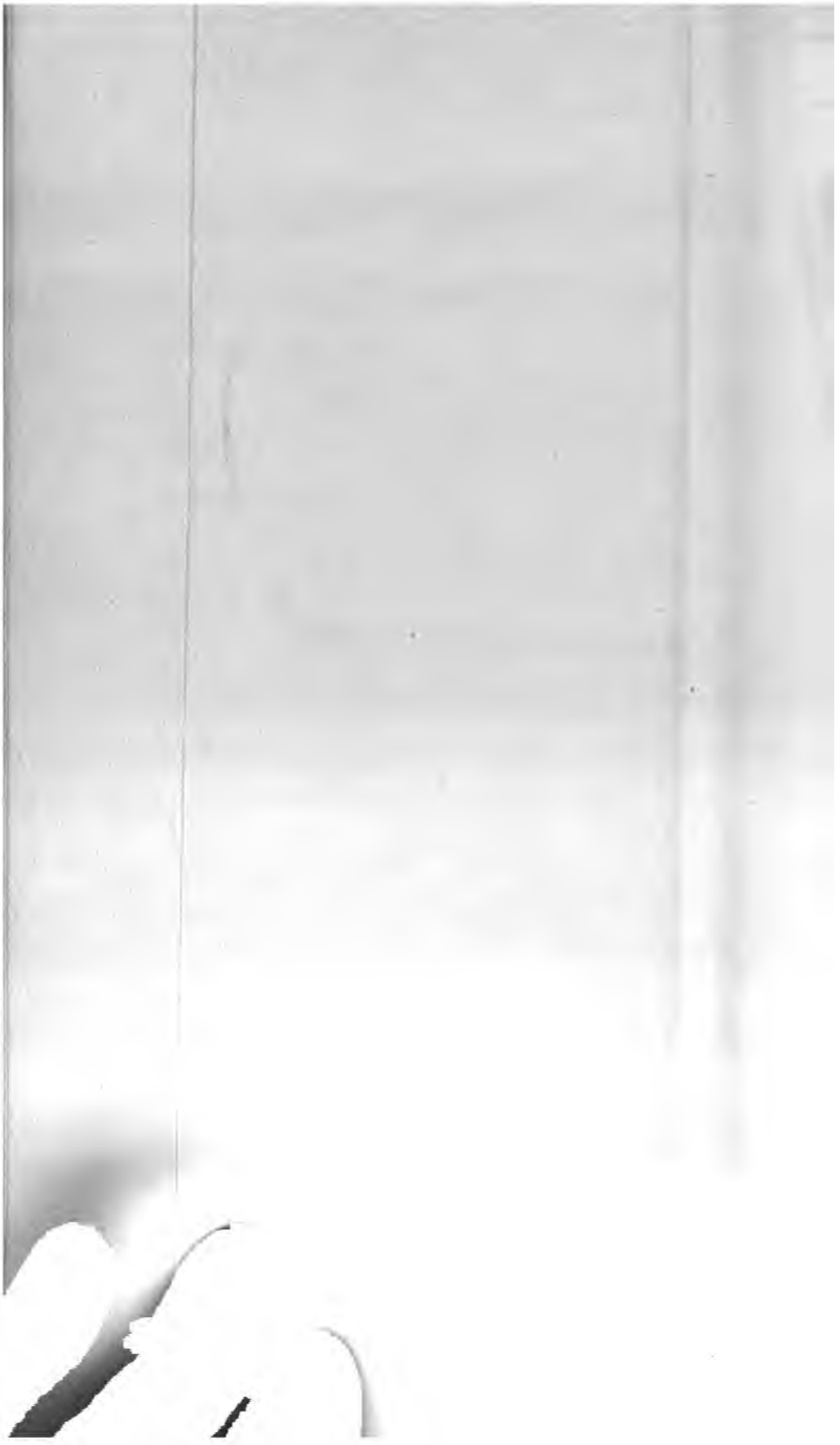
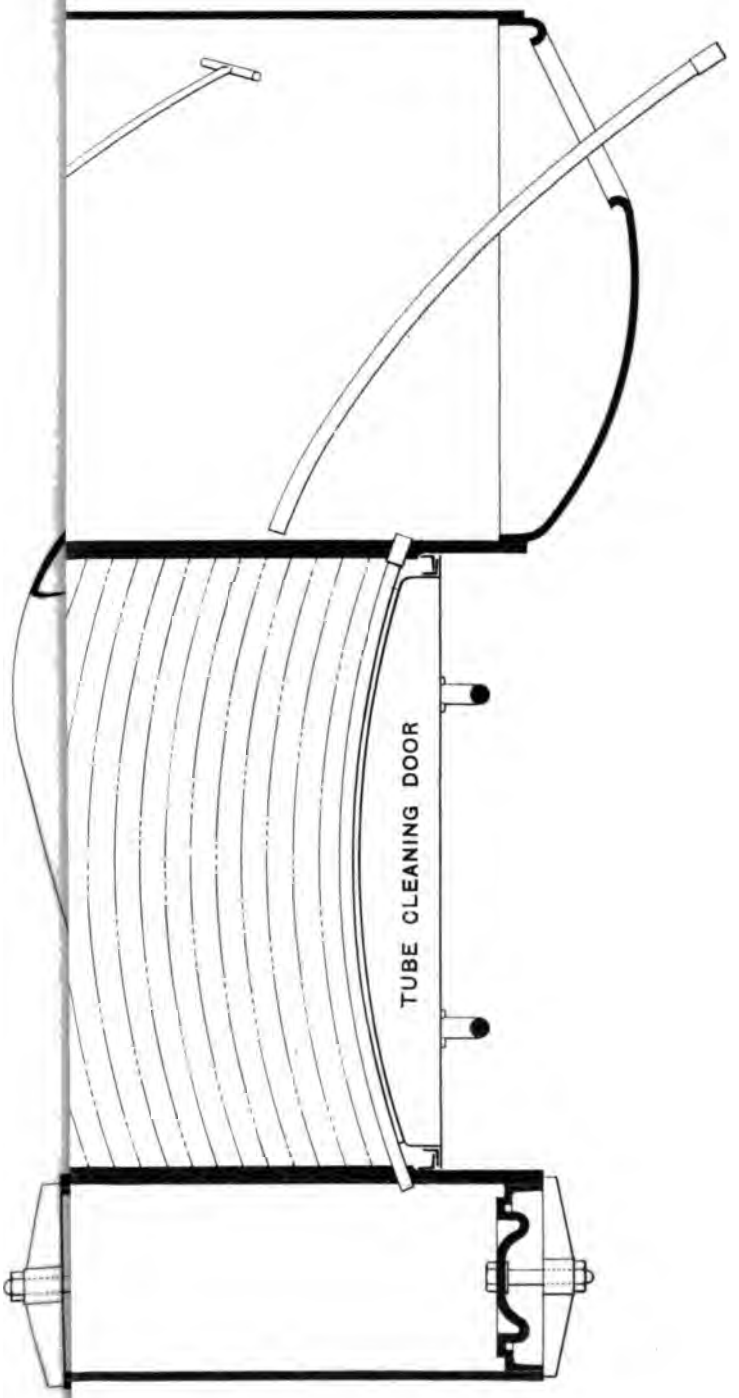


r on "Water Tube Boilers."



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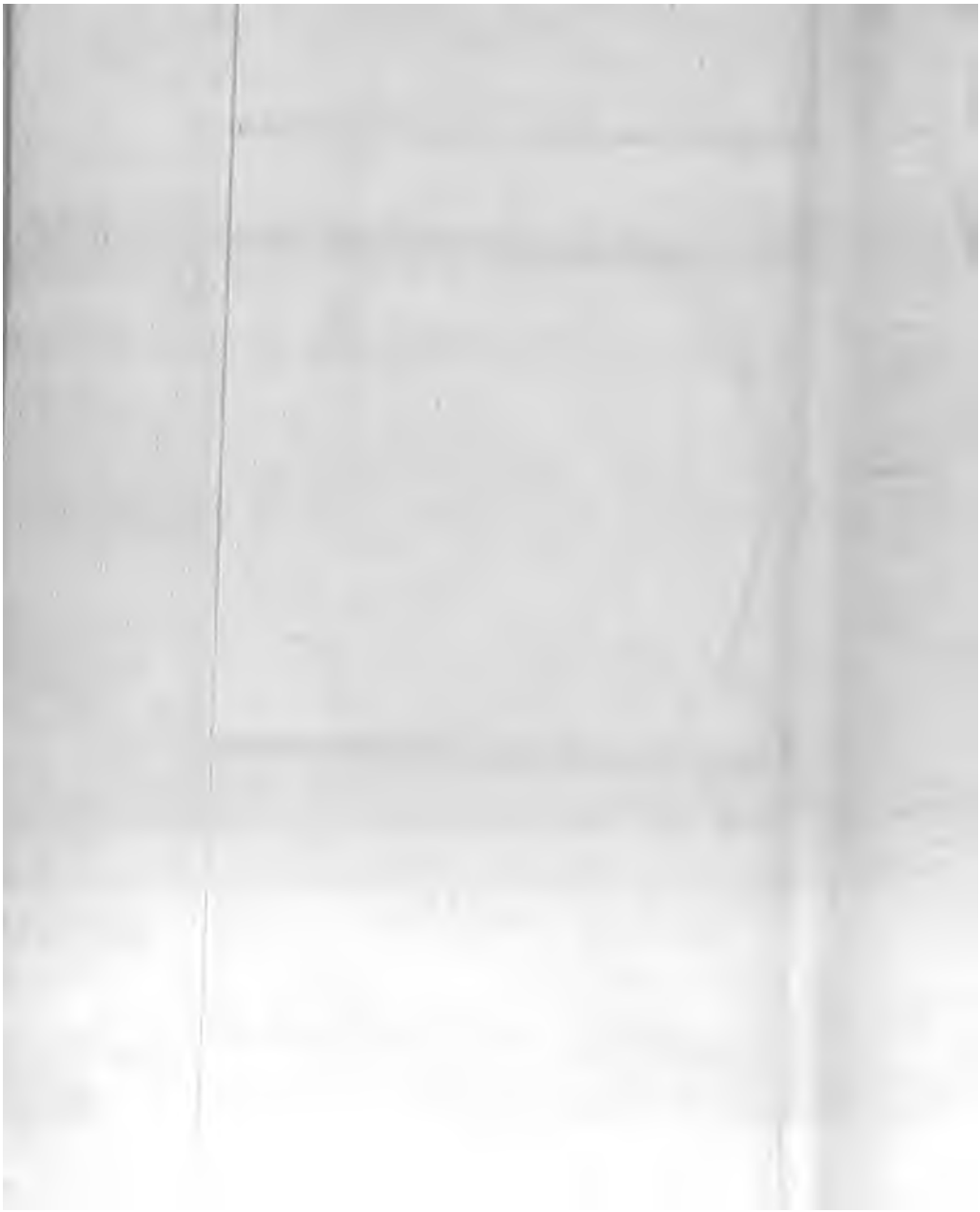

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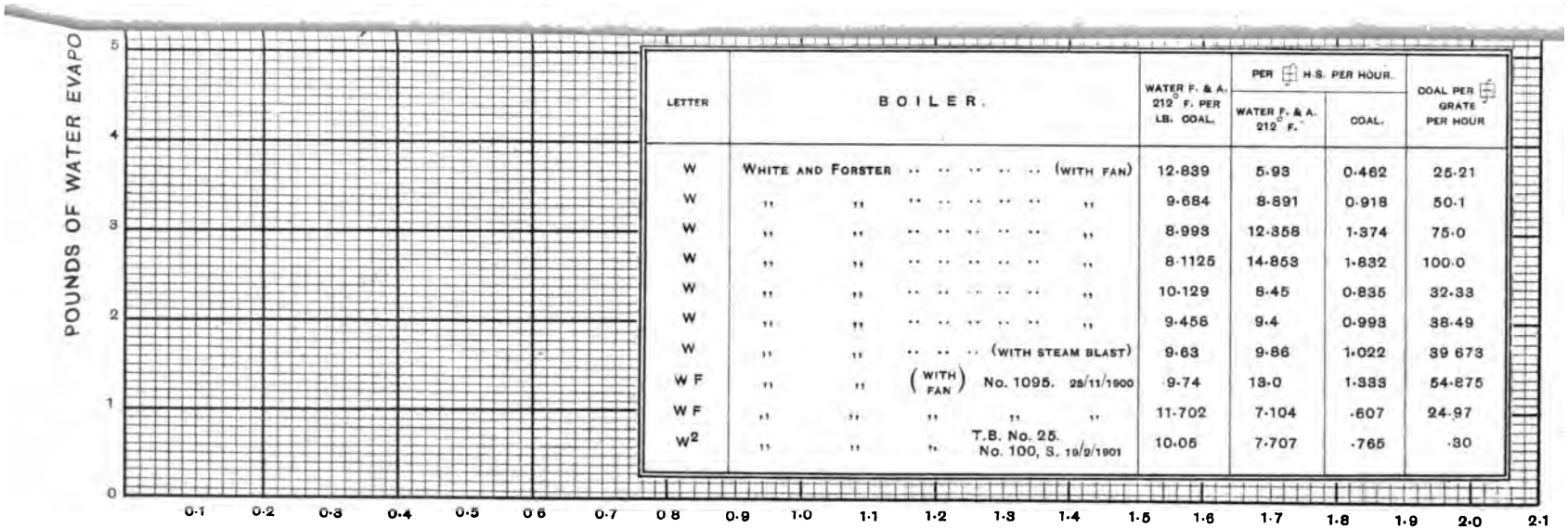

LETTER	BOILER.	WATER F. & A. 212° F. PER LB. COAL.	PER ⊟ H.S. PER HOUR. WATER F. & A. 212° F.	PER ⊟ H.S. PER HOUR. COAL.	COAL PER ⊟ GRATE PER HOUR
W	WHITE AND FORSTER .. .. (WITH FAN)	12·839	5·93	0·462	25·21
W	,, ,, ... ,,	9·684	8·891	0·918	50·1
W	,, ,, ... ,,	8·993	12·358	1·374	75·0
W	,, ,, ... ,,	8·1125	14·853	1·832	100·0
W	,, ,, ... ,,	10·129	8·45	0·835	32·33
W	,, ,, ... ,,	9·456	9·4	0·993	38·49
W	,, ,, ... (WITH STEAM BLAST)	9·63	9·86	1·022	39 673
W F	,, ,, (WITH FAN) No. 1095. 28/11/1900	9·74	13·0	1·333	54·675
W F	,, ,, ,, ,, ,,	11·702	7·104	·607	24·97
W^2	,, ,, ,, T.B. No. 25. No. 100, S. 19/2/1901	10·05	7·707	·765	·30

POUNDS OF COAL BURNED PER SQUARE FOOT OF HEATING SURFACE PER HOUR.

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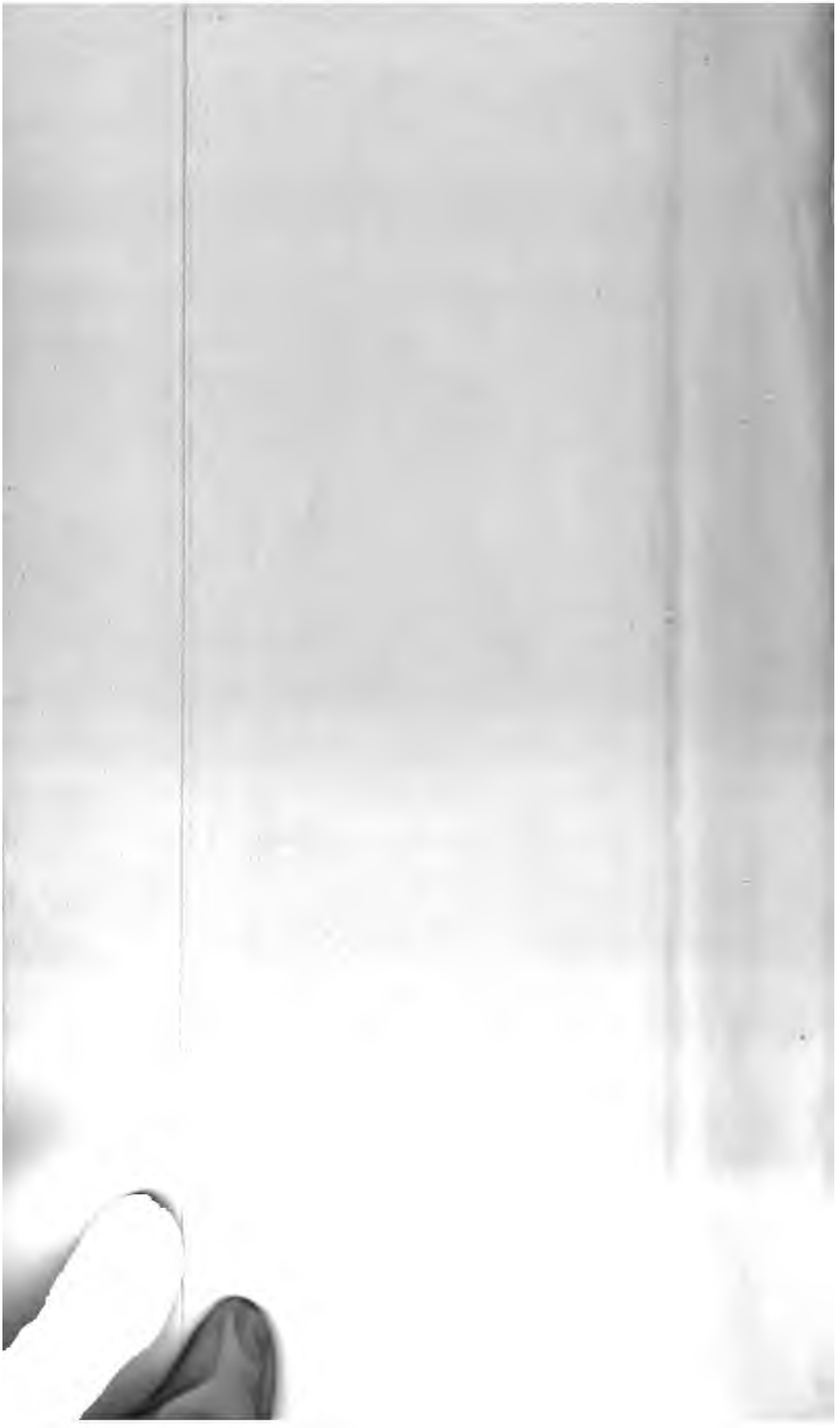

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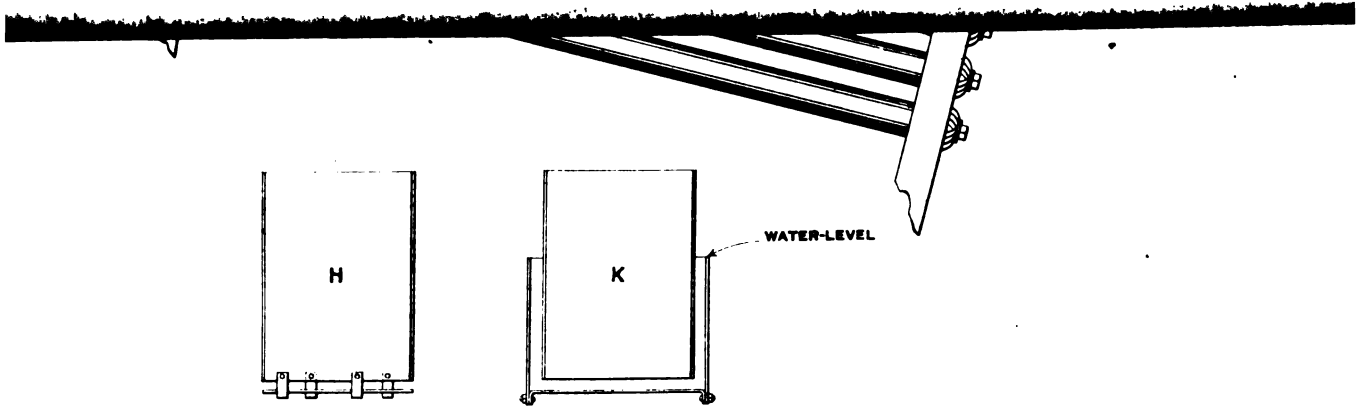

DRUM MARKED H, FITTED WITH PARTIALLY-CLOSED BOTTOM, THE WATER-LEVEL IN DRUM CORRESPONDING TO LEVEL IN BOILER.

DRUM MARKED K, FITTED WITH PASSAGES UP THE SIDES, GIVING FIXED WATER LEVEL IN DRUM FOR SCUMMING, IRRESPECTIVE OF LEVEL IN BOILER

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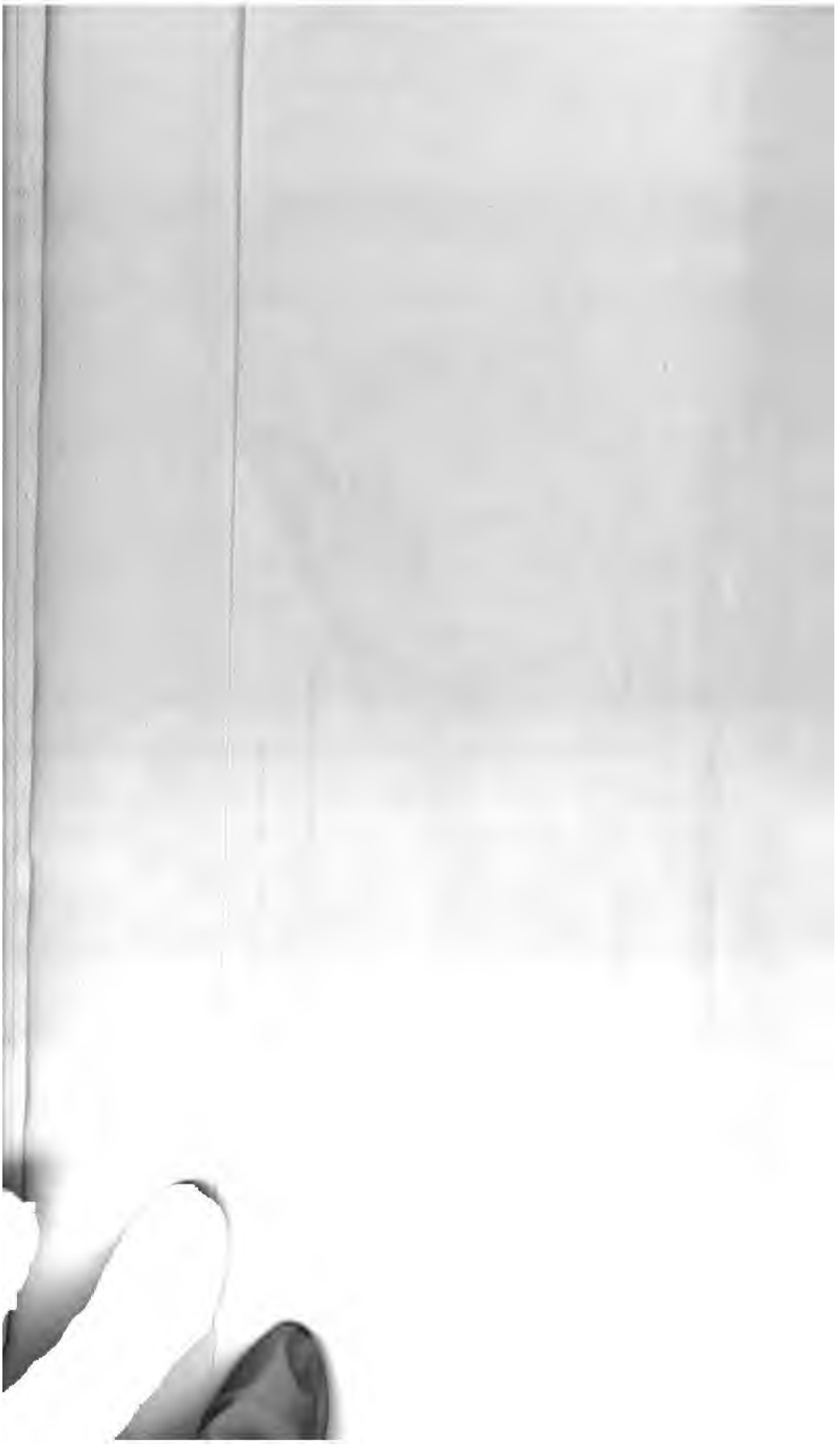
PUMP-ROD FROM A MAILBOAT SANITARY PUMP, AFTER FIVE MONTHS' WORK IN SALT WATER.
25 PER CENT. NICKEL STEEL. DIAMETER OF ROD 2½ INCHES.



PUMP-ROD FROM A MAILBOAT SANITARY PUMP, AFTER FIVE MONTHS' WORK IN SALT WATER.

25 PER CENT. NICKEL STEEL. DIAMETER OF ROD 2½ INCHES.

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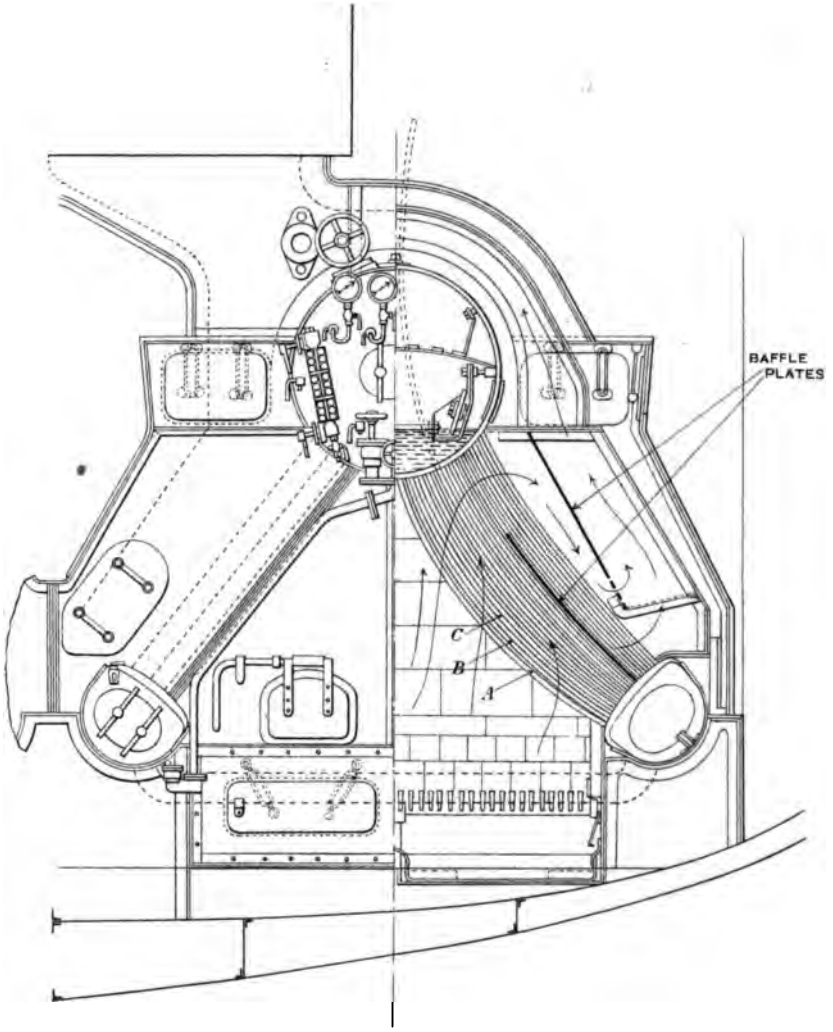

BLECHYNDEN WATER TUBE BOILER

(CRUISER TYPE).

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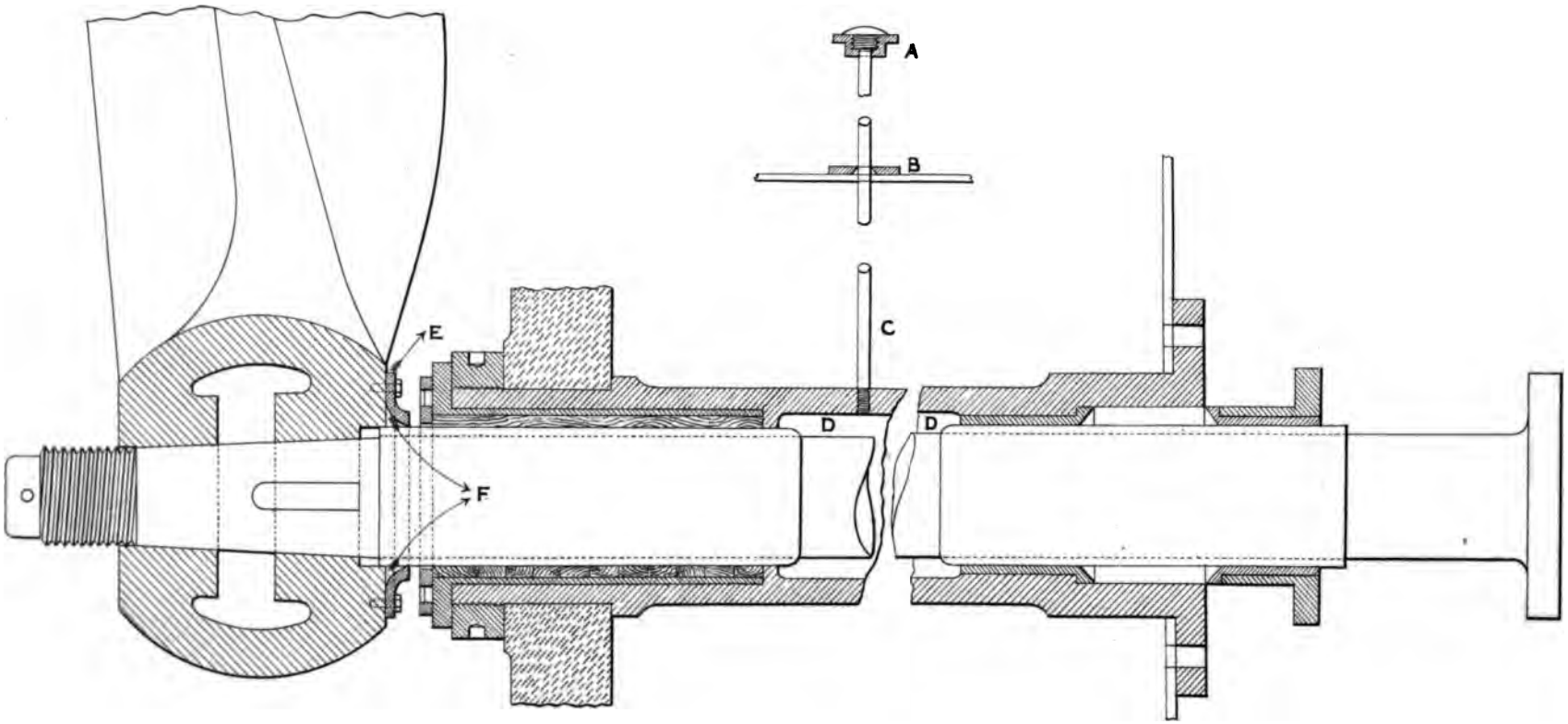

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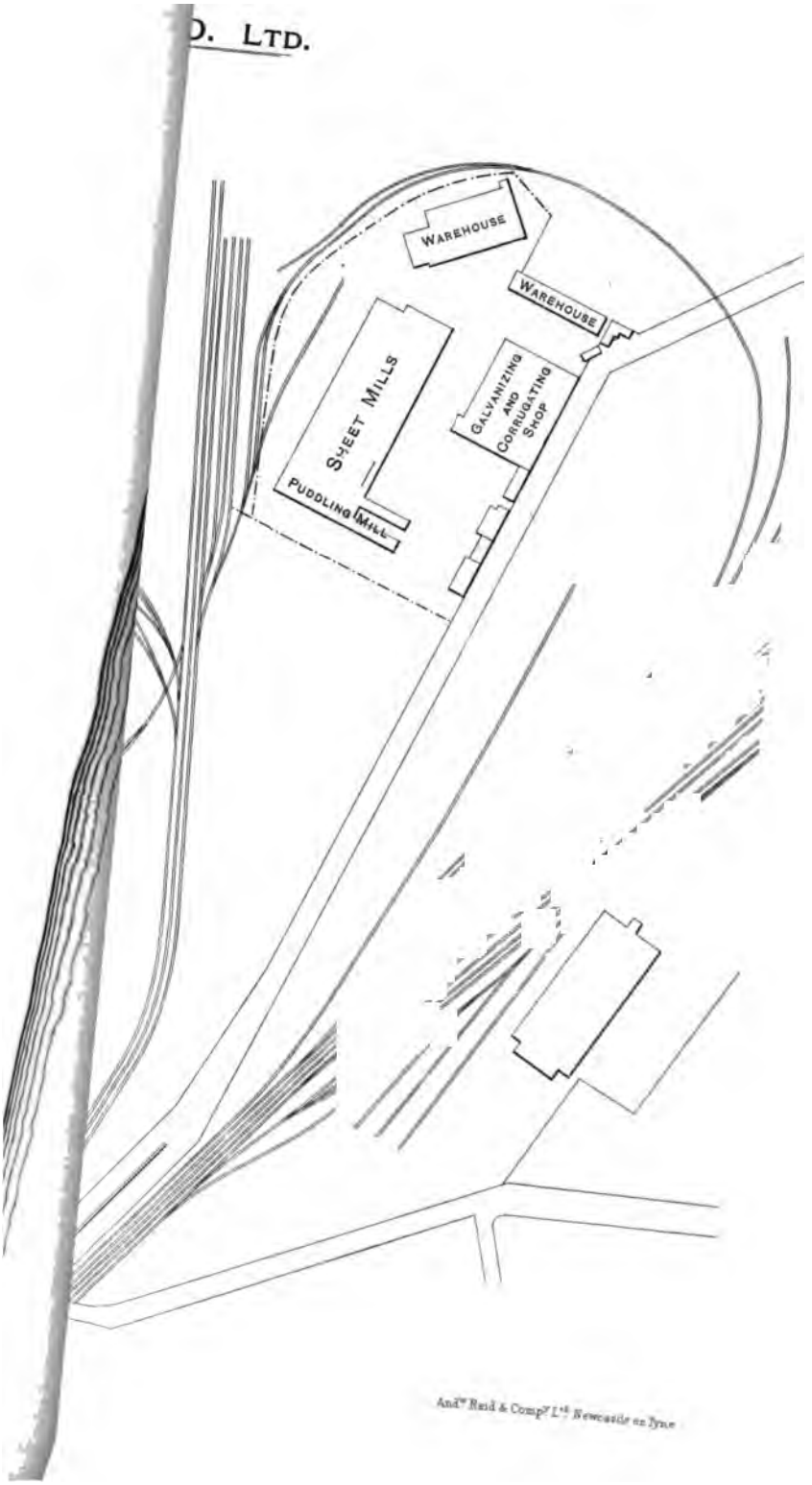
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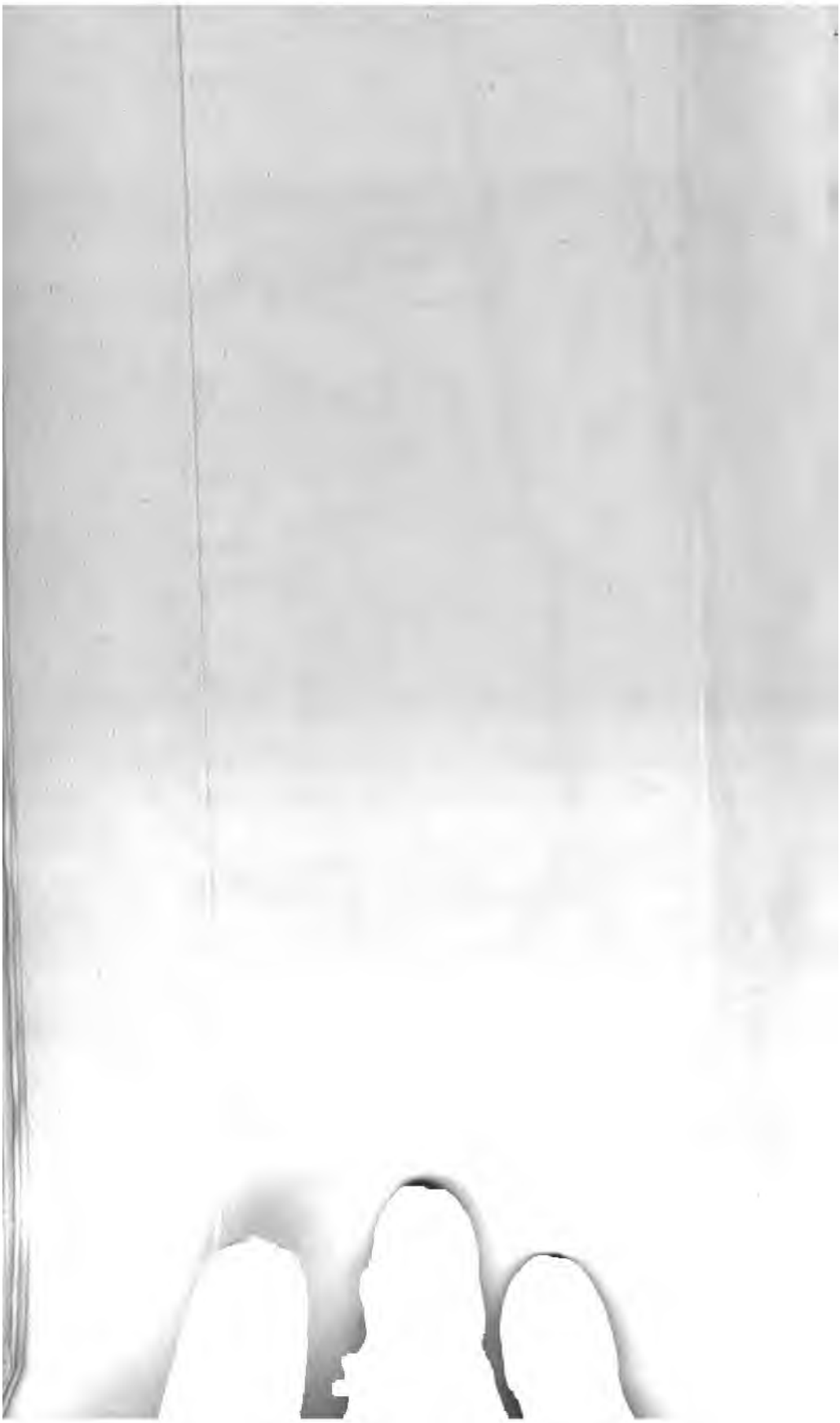

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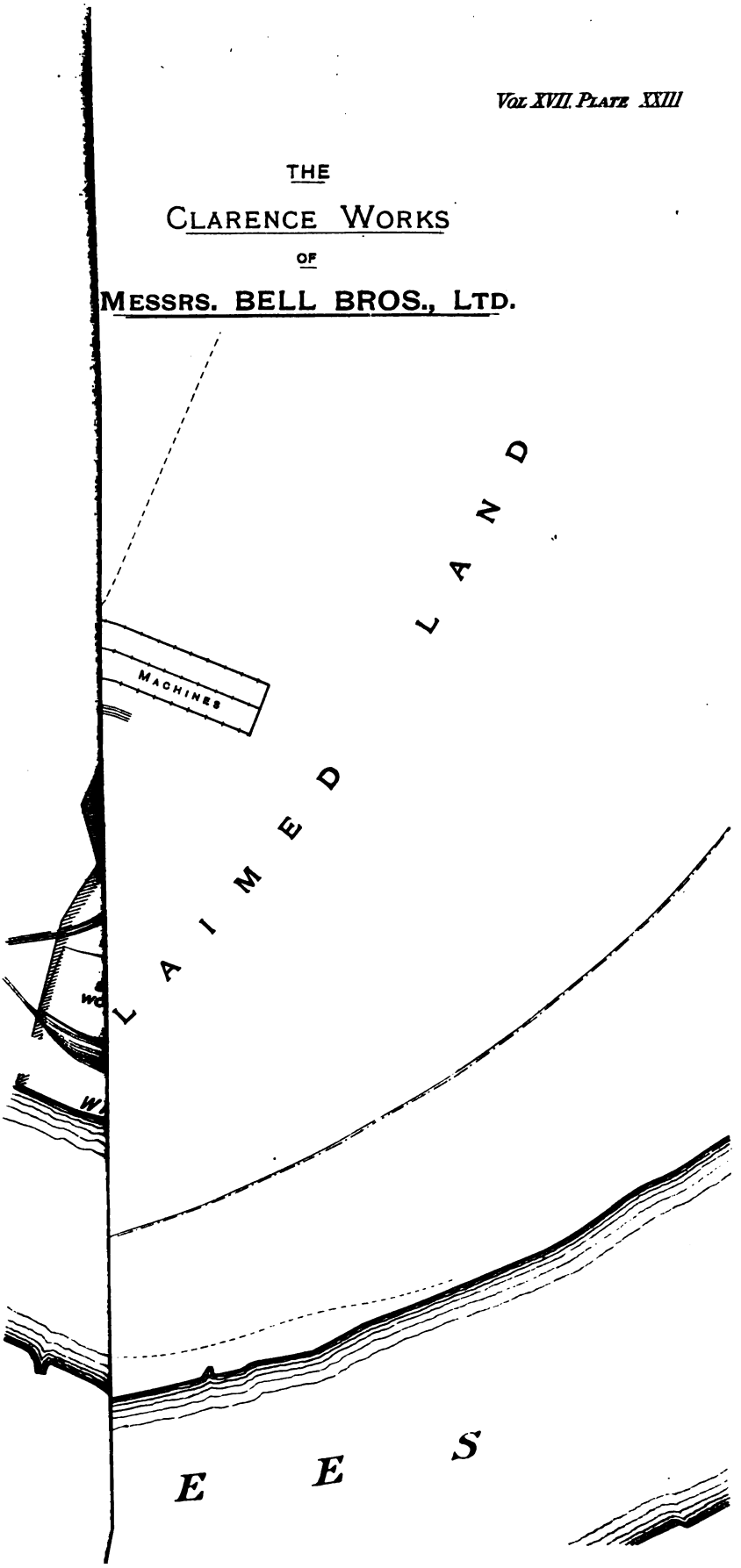

Issued September, 1901

Vol. XVII. SESSION 1900-1901. Part 9.

TRANSACTIONS

OF THE

NORTH-EAST COAST INSTITUTION

OF

Engineers & Shipbuilders.

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Members are requested to examine the new list of Members, Associates, and Graduates, and report at once to the Secretary any error which may occur therein. The Secretary will be glad to receive information respecting those whose addresses are omitted from the list.

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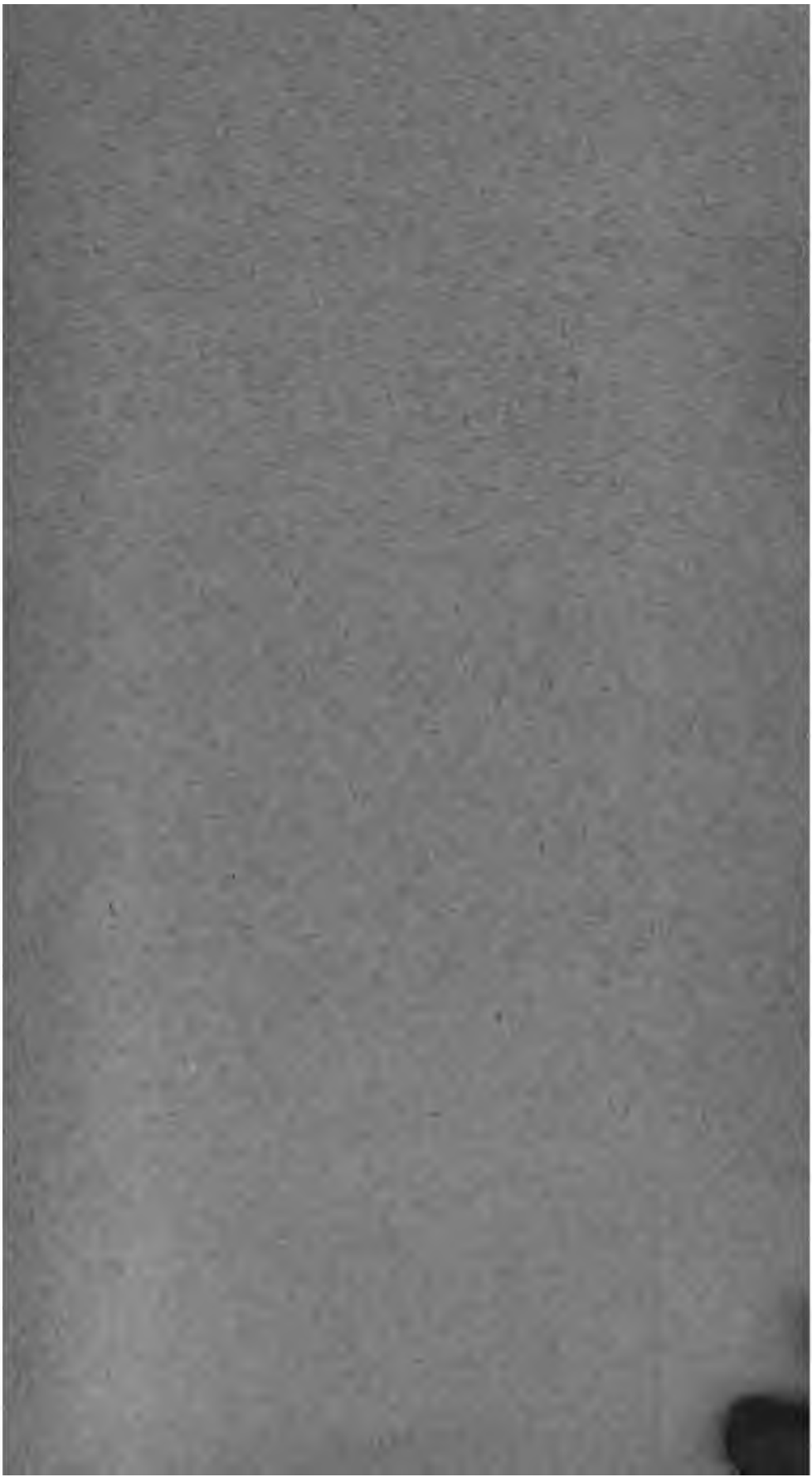

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